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Buffer Techniques For Stochastic Resource Constrained Project Scheduling With Stochastic Task Insertions Problems

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BUFFER TECHNIQUES FOR
STOCHASTIC RESOURCE CONSTRAINED PROJECT SCHEDULING
WITH STOCHASTIC TASK INSERTIONS PROBLEMS

by

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ABSTRACT

Project managers are faced with the challenging task of managing an environment filled with uncertainties that may lead to multiple disruptions during project execution. In particular, they are frequently confronted with planning for routine and non-routine unplanned work: known, identified, tasks that may or may not occur depending upon various, often unpredictable, factors. This problem is known as the stochastic task insertion problem, where tasks of deterministic duration occur stochastically. Traditionally, project managers may include an extra margin within deterministic task times or an extra time buffer may be allotted at the end of the project schedule to protect the final project completion milestone. Little scientific guidance is available to better integrate buffers strategically into the project schedule.

Motivated by the Critical Chain and Buffer Management approach of Goldratt, this research identifies, defines, and demonstrates new buffer sizing techniques to improve project duration and stability metrics associated with the stochastic resource constrained project scheduling problem with stochastic task insertions. Specifically, this research defines and compares partial buffer sizing strategies for projects with varying levels of resource and network complexity factors as well as the level and location of the stochastically occurring tasks.

Several project metrics may be impacted by the stochastic occurrence or non-occurrence of a task such as the project makespan and the project stability. New duration and stability metrics are developed in this research and are used to evaluate the effectiveness of the proposed buffer sizing techniques. These “robustness measures” are computed through the comparison of

the characteristics of the initial schedule (termed the infeasible base schedule), a modified base schedule (or as-run schedule) and an optimized version of the base schedule (or perfect knowledge schedule).

Seven new buffer sizing techniques are introduced in this research. Three are based on a fixed percentage of task duration and the remaining four provide variable buffer sizes based upon the location of the stochastic task in the schedule and knowledge of the task stochasticity characteristic. Experimental analysis shows that partial buffering produces improvements in the project stability and duration metrics when compared to other baseline scheduling approaches. Three of the new partial buffering techniques produced improvements in project metrics. One of these partial buffers was based on a fixed percentage of task duration and the other two used a variable buffer size based on knowledge of the location of the task in the project network.

This research provides project schedulers with new partial buffering techniques and recommendations for the type of partial buffering technique that should be utilized when project duration and stability performance improvements are desired. When a project scheduler can identify potential unplanned work and where it might occur, the use of these partial buffer techniques will yield a better estimated makespan. Furthermore, it will result in less disruption to the planned schedule and minimize the amount of time that specific tasks will have to move to accommodate the unplanned tasks.

This work is dedicated to my precious children, Kaitlyn and Nicholas, who both literally lived through different portions of this process with me.

"Dr. Mom" - I started this journey seeking the former title, but completed it with the greatest distinction I could ever hope to have, times two.

"I pray that God would fill your heart with dreams
and that faith gives you the courage
to dare to do great things.
I'm here for you whatever this life brings,
so let my love give you roots
and help you find your wings.
I'll have tears as you take off,
but I'll cheer as you fly."
- Mark Harris

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LIST OF ABBREVIATIONS

Ψ_g = state of knowledge of tasks at decision stage g

$\beta^*(\Psi_g)$ = an optimal solution policy for the SRCP that determines the set of task times $d_g^*(\Psi_g)$

n (Ψg) = a subspace of implementable functions of tasks

b_k^g = total availability of resource type k at decision stage g

CC/BM = critical chain scheduling and buffer management

CCS = critical chain schedule

C_g = set of tasks completed at or before the time of occurrence of decision stage g

CI = complexity index

CNC = coefficient of network complexity

d = project duration of the perfect knowledge schedule

D = project duration of the modified base schedule

d_m = duration of activity m

DRCP = deterministic resource constrained problem

EH = early, high setting (high number of stochastic tasks occurring in the first half of the network)

EL = early, low setting (low number of stochastic tasks occurring in the early half of the network)

g = decision stage

I = set of indices of tasks which must precede task m

JG3 = (duration of current stochastic task)/(sum of all potential stochastic task durations)

JG4 = (task stochastic number) x(JG3)

JG5 = (current stochastic task duration) x (1 - % of total project activity time remaining)

JG6 = (current stochastic task duration) x (1 - % of total potential stochastic task activity time remaining)

k = number of resource types

LH = late, high setting (high number of stochastic tasks occurring in the latter half of the network)

LL = late, low setting (low number of stochastic tasks occurring in the latter half of the network)

LS = location of stochasticity

LVS = level of stochasticity

m = tasks for 1 to M

M = number of tasks in project

OL = optimistic schedule where the low level of stochastic tasks (8) are not included in the schedule

OH = optimistic schedule where the high level of stochastic tasks (16) are not included in the schedule

OS = order strength

P = pessimistic schedule where all of the stochastic tasks are included in the schedule

PD = total project duration

PR = set of precedence relations

Q_m = set of indices of planned tasks that must precede task m

r_k = total availability of resource k

R_{mk} = amount of resource k required by activity m

RC = resource constrainedness

RCPSP = resource constrained project scheduling problem

RF = resource factor

RS = resource strength

RU = resource use

s_m = start time of task m

S_g = set of tasks in process at decision stage g

SN_m = stochastic resource constrained problem

SRCP = stochastic resource constrained project scheduling problem

STI = stochastic task insertion

CHAPTER ONE: OVERVIEW OF RESEARCH

Project managers are faced with the challenging task of managing an environment that is filled with uncertainties that may lead to multiple disruptions during project execution. This research identifies, defines and demonstrates new buffer sizing techniques to improve project duration and stability metrics associated with the stochastic resource constrained project scheduling problem with stochastic task insertions (SRCP with STI) where tasks with deterministic duration occur stochastically. In addition, a new project stability metric is developed to account for variations in task start times.

Most tasks in a project environment are estimated and scheduled with a deterministic duration, when in fact, due to uncertainties inherent in the environment, the duration is actually stochastic in nature (the SRCP). To account for this uncertainty, project managers may include an additional time allotment within each task in the baseline schedule to protect against exceeding the projected project completion milestone. This is a form of buffering in which tasks with deterministic duration are simply extended by an arbitrary amount of time. Another manner by which the project manager may choose to address task time uncertainty is to schedule all of the tasks at their estimated duration and then add on an additional arbitrary block of time at the end of the schedule. This can be viewed as a project buffer. The idea behind this approach is that as long as the individual task time overruns do not encroach beyond the final buffer at the end of the schedule, the project completion milestone will still be met. Unfortunately for the project manager, very little research has been conducted into the SRCP in general and almost none of it has addressed the notion of buffers as a means to manage project uncertainty, leaving no scientific recommendations for sizing buffers.

The use of buffers in project scheduling, known as Critical Chain Scheduling and Buffer Management (CC/BM), was proposed by Goldratt in (1997) in his book *Critical Chain*. The CC/BM method specifically addresses the issue of task duration variability considered to be inherent in every task time estimate provided to a project scheduler and therefore, although not specifically stated, it provides a general approach to addressing the stochastic resource constrained project scheduling problem. Several researchers have noted some potential pitfalls with the CC/BM approach and these are discussed in Chapter Three. The CC/BM approach does not, however, address the SRCP with STI problem.

According to an exhaustive search of the literature, Selim (2002) is the first and only research investigation into the SRCP with STI problem utilizing extreme buffer sizing and insertion techniques. The research, however, did not specifically define or identify the fact that the pessimistic and optimistic scheduling approaches used could be interpreted as extreme buffer sizing techniques. Selim (2002) developed robustness measures to compare the scheduling metrics (both makespan/duration and stability/re-sequencing) that resulted from implementing various baseline scheduling approaches and subsequent rescheduling policies. The baseline schedules developed were defined as optimistic and pessimistic approaches. The optimistic schedule assumed that none of the stochastically occurring tasks would occur and therefore, none of the stochastically occurring tasks were scheduled. This approach can be equated to a zero buffer policy where no time allotment is made for the potential of a stochastic task occurring. The pessimistic schedule utilized by Selim (2002), assumed the opposite perspective in which all stochastic tasks were assumed to occur and therefore, all were scheduled at the full duration estimate. This approach can be equated to a complete buffering policy where total allotment for the duration of each potentially occurring stochastic task is included in the schedule. The zero and complete buffering approaches of the optimistic and pessimistic schedules can be viewed as extreme buffering approaches.

Selim (2002) developed a set of project duration (makespan) and task sequence-related (stability) robustness measures to evaluate the performance of each of the baseline schedules (optimistic and pessimistic) as compared to both a modified base schedule (as-run schedule) and a perfect knowledge schedule. The modified base schedules were obtained utilizing two different rescheduling policies depending upon the initial baseline scheduling approach used. With the optimistic baseline scheduling approach, in which no time allotment was made for any potentially occurring stochastic tasks (no buffer was inserted), a right-shift policy was utilized to reschedule the remaining tasks when a stochastic task insertion was required. With the pessimistic baseline scheduling approach, in which 100% time allotment was given for all potentially occurring stochastic tasks (complete buffering was utilized), a left shift policy was utilized to reschedule the tasks if the stochastic tasks did not occur. With both of the rescheduling policies, the protocol was to minimize the changes to the task sequence and therefore, existing optimal makespan scheduling procedures were not utilized. The perfect knowledge scheduling approach, however, did utilize optimal makespan scheduling procedures to obtain the optimal schedule assuming a priori knowledge of stochastic task occurrence or non-occurrence.

Selim (2002) also investigated the effects of various network and resource factors on the robustness of the schedule as well as the location of the stochasticity. The entire experiment was repeated to analyze the effects of the level of stochasticity (a low or high number of stochastically occurring tasks) on the robustness measures. Selim (2002) provided an excellent initial examination of utilizing extreme buffer insertion techniques to produce robust baseline schedules for stochastic task insertion problems.

One of the major contributions of the current research is defining and demonstrating the improvements that can be made in project duration and stability metrics utilizing a partial buffering approach. In this research, tasks that are determined to be potentially stochastically occurring are scheduled for a duration that is based upon partial buffer sizing rules developed and validated in this research. Seven partial buffering techniques are studied in an initial experiment. Three are based on a fixed percentage of estimated task duration and the remaining four allocate a variable percentage of estimated duration based on knowledge of the stochasticity characteristics. Phase one of this research conducts an experiment to determine which of the seven partial buffering strategies produced the most promising results when comparing the project duration and stability metrics of the baseline schedule to the perfect knowledge schedule. The partial buffering rules with the best performance results were used to generate the modified ("as-run") baseline schedules for phase two of the research.

In order to accurately compare the extreme and partial buffering approaches, the network, resource, and stochastic factors analyzed in Selim (2002) were replicated. The factors included in the experiment were network topology (a combination of order strength and complexity index), resource characteristics (a combination of resource factor and resource constrainedness), and the location of stochasticity in the network. The experiment was conducted twice for varying levels of stochasticity (a low and a high number of stochastic tasks) similar to the approach used in Selim (2002).

Based on these results, buffer strategies for networks of varying resource parameters, network factors and stochasticity factors were defined. The results will aid project schedulers in knowing under which circumstances it is appropriate to buffer a schedule, and by how much the schedule should be buffered.

Chapter Two presents a literature review of project scheduling under uncertainty. The goals of this chapter are twofold: 1) provide the project scheduling background necessary to define the stochastic task insertion problem and 2) categorize the buffer insertion and management technique as proposed by Goldratt (1997) within the existing approaches for dealing with uncertainty in project scheduling. Chapter Three provides an overview of the Critical Chain Scheduling and Buffer Management (CC/BM) technique as proposed by Goldratt (1997) and a thorough review of all known research that expands upon these techniques. Chapter Four presents a description of how the partial buffering approach can be applied to SRCP with STI problems. Chapter Five presents a description of the types of networks investigated in this research, the proposed factors for investigation and the experimental design. Chapter Six presents a detailed description of the experimental process. The results and analysis are presented in Chapter Seven and the final conclusions for further research are presented in Chapter Eight.

CHAPTER TWO: PROJECT SCHEDULING UNDER UNCERTAINTY REVIEW

A project is defined as a unique series of resource-constrained activities with a defined start and end time that seeks to meet a specific objective (Elsayed and Boucher 1994; Kerzner 1995). It is a well-known fact that project activities are subject to considerable uncertainty, which may lead to multiple schedule disruptions during project execution. As a result, the random nature of activity durations has been the subject of numerous research efforts since the introduction of the initial PERT model (Malcolm, Roseboom et al. 1959; Adlakha and Kulkarni 1989; Valls, Laguna et al. 1999; Stork 2001). The majority of resource-constrained project scheduling research however assumes complete information about the scheduling problem to be solved and a static deterministic environment in which the pre-computed baseline schedule will be executed. This type of problem definition is known as the general deterministic resource constrained project scheduling problem (DRCP). The vast majority of project scheduling research focuses on this type of problem where the objective is to minimize the project duration subject to precedence relationships and limited resources under the non-preemption assumption.

Deterministic Resource Constrained Project Scheduling

The DRCP has been formulated as follows: (Cheng and Gen 1994)

Objective: minimize PD

Constraints,

subject to $s_n - s_m \geq d_m \ \forall (m, n) \in PR$

$$\sum_{m \in At} R_{mk} \leq r_k \quad \forall k$$

where, A_t = is the set of activities in process at time t

d_m = duration of activity m

k = number of resource types

PD = total project duration

PR = set of precedence relations

r_k = total availability of resource k

R_{mk} = amount of resource k required by activity m

s_m = start time of task m

Assumptions,

1. There are limited resources. That is, all precedence eligible activities cannot be scheduled due to resource limitations.
2. Once started, a job cannot be interrupted (also called non-preemptive).

When task duration variability is taken into account, the problem formulation is known as the Stochastic Resource Constrained Project Scheduling Problem (SRCP). Research in this area is sparse and focuses primarily on determining the project duration distribution rather than the start times of the tasks (Fernandez 1995). Selim (2002) notes that several classification methods for the SRCP can be used including scheduling objectives (Moo Young 1995), the distribution of project duration and the method to find the task start times (Fernandez 1995; Fernandez, Armacost et al. 1997). A method for generating a baseline schedule for the stochastic resource constrained project scheduling problem does not exist in the literature. Instead, the solution to the stochastic resource constrained project scheduling problem can be viewed as a dynamic process that makes scheduling decisions at specific points in time.

Stochastic Resource Constrained Project Scheduling

The SRCP with stochastic task durations can be formulated as follows:

Find a policy $\beta^*(\Psi_g)$ that optimizes a given objective function

Subject to:

$s_m \geq s_m+1 + d_m+1 \quad \forall_m \in M,\ \forall_{m+1} \in Q_m,\ m \notin C_g,\ m \notin S_g$ *(precedence constraints)*

$\sum_{i \in Og} r_{ik} \leq b_k^{\,g}, \forall g, \forall_k$ *(resource constraints)*

$\beta^*(\Psi_g) \in n\ (\Psi_g)\ ,\ \forall g$ *(nonanticipativity constraint)*

where,

Ψ_g = *state of knowledge of tasks at decision stage g*

$\beta^*(\Psi_g)$ = *an optimal solution policy for the SRCP that determines the set of task times* $d_g^*(\Psi_g)$

$n\ (\Psi g)$ = *a subspace of implementable functions of tasks*

b_k^g = *total availability of resource type k at decision stage g*

C_g = *set of tasks completed at or before the time of occurrence of decision stage g*

d_m = *duration of activity m*

g = decision stage

I = set of indices of tasks which must precede task m

k = number of resource types

m = tasks for 1 to M

M = number of tasks in project

Q_m = *set of indices of planned tasks which must precede task m*

r_k = *total availability of resource k*

s_m = *start time of task m*

S_g = *set of tasks in process at decision stage g*

SRCP = stochastic resource constrained problem

The real world is not static and the probability that a baseline schedule, (pre-computed schedule, pre-schedule, or predictive schedule) will be implemented exactly as planned is low (Demeulemeester and Herroelen 2002; Herroelen and Leus 2004b). Baseline schedules however are crucial to project success. The primary purposes of a baseline schedule are: 1) to serve as a basis for coordinating internal and external activities such as material procurement, preventative maintenance and shipping dates, 2) to allocate resources to different jobs to optimize some measure of performance and 3) to serve as a means of communication to coordinate the inbound and outbound supply chain (Wu, Storer et al. 1993; Mehta and Uzsoy 1998; Aytug, Lawley et al. 2005; Herroelen and Leus 2005a).

The challenge of resource constrained project scheduling is to develop a baseline schedule that incorporates enough variability to remain robust against the guaranteed minor schedule fluctuations that result from the uncertainty inherent in a project environment (robust scheduling, proactive scheduling, or predictive scheduling) and yet still be able to react to the unforeseen major fluctuations that inevitably occur (reactive scheduling). This approach is known as predictive-reactive scheduling and has recently received considerable attention in the project scheduling literature (Leus 2003; Leus and Herroelen 2004; Herroelen and Leus 2004b). Although this approach is the ideal practice in industry, the mathematical and theoretical rigor required to conduct research in this area proves that solutions to problems such as these are computationally intractable (Blazewicz, Lenstra et al. 1983) and thus, many heuristic solution approaches have been proposed (Icmeli, Erenguc et al. 1993; Özdamar and Ulusoy 1995; Herroelen, De Reyck et al. 1998; Weglarz 1998; Brucker, Drexl et al. 1999; Kolisch and Padman 2001; Demeulemeester and Herroelen 2002). Goldratt's Critical Chain and Buffer Management methodology can be categorized as a predictive-reactive heuristic solution to the Stochastic Resource Constrained Project Scheduling Problem (SRCP) and will be discussed in detail in Chapter Three.

As summarized in Herroelen and Leus (2005a), recent research efforts have sought to manage uncertainty by utilizing one of six approaches: reactive scheduling, stochastic scheduling, scheduling under fuzziness, sensitivity analysis or proactive (robust) scheduling and GERT. Two of the most important distinctions between these approaches is how uncertainty is accounted for in the baseline schedule and the manner by which decisions are made during project execution to react to disruptions. The six approaches vary drastically from one extreme of not generating a baseline schedule but, instead utilizing a dynamic scheduling policy to schedule tasks depending upon the state of the project at certain points in time to the other extreme of generating a baseline schedule with no anticipation of variability and then utilizing a predetermined reactive scheduling policy as schedule variations occur. Given the importance of a baseline schedule, as described previously, neither of these approaches would be considered ideal in practice. A third distinction among the approaches is the evolution structure of the project network. GERT networks deal with projects that have a stochastic evolution structure whereas the other methods have a network structure that is specified in advance (each activity is carried out exactly once during a single project execution and it is not possible to return to previously performed activities). A review and classification of the six approaches for dealing with uncertainty is outlined in this chapter.

Reactive Scheduling

The process of modifying the predictive or baseline schedule in the face of operational disruptions is generally referred to as reactive scheduling or rescheduling. Reactive scheduling takes place at the time of the execution of the schedule (Davenport and Beck 2002). The nature of the schedules developed in reaction to disruptions depends on the nature of the realized disruptions and the capabilities of the execution agent reacting to them. The reaction generally takes the form of either modifying the existing predictive schedule (schedule repair actions), or generating a completely new schedule that is followed until the next disruption occurs (full rescheduling) (Aytug, Lawley et al. 2005). Extensive reactive scheduling research has been conducted in the manufacturing environment (Szelke and Kerr 1994; Sabuncuoglu and Bayiz 2000; Vieira, Herrmann et al. 2003).

An example of a schedule repair action is the right-shift rule which moves forward in time all the activities that are affected by the schedule breakdown (Sadeh, Otsuka et al. 1993; Smith 1994). It should be clear that this strategy may lead to poor results as it does not re-sequence activities. There are many full-rescheduling heuristics that depend upon the project objective function. Minimum perturbation strategies seek to generate a new schedule that deviates from the original schedule as little as possible (ex post stability). Several researchers have studied this type of solution with various objective functions including the minimization of the sum of the (weighted) absolute difference between the start time of each activity in the repaired schedule and the original start time of that activity (El Sakkout and Wallace 2000), and minimizing the number of activities to be performed on different resource units (Alagöz and Azizoglu 2003). Another objective studied is to minimize the number of changed activities utilizing goal programming (Calhoun, Deckro et al. 2002). Match-up scheduling is an approach that finds the time instance where the state reached by the revised schedule is the same as the initial schedule (Bean, Birge et al. 1991; Wu, Storer et al. 1993; Akturk and Gorgulu 1999; Alagöz and Azizoglu 2003). Artigues and Roubellat (2000) proposed a method utilizing a clever rescheduling pass for inserting an unplanned task into an existing schedule such that the resulting impact on maximum lateness is minimized.

Stochastic Project Scheduling

As discussed previously, the problem of scheduling a project of n activities under resource and precedence restrictions with the objective of minimizing the makespan is referred to as the (classical) resource constrained project scheduling problem (RCPSP) in the literature. When the durations of activities are not known in advance, but instead are given by a random vector $\boldsymbol{d = (d_1\ d_2 \ldots d_n)}$ where d_i is the random duration of i and d has a known probability distribution, this problem is called the stochastic RCPSP or the RCPSP with stochastic durations (Stork 2000). Related problems in stochastic RCPSP include the special case of stochastic activity interruptions, time/cost trade-off problems and the stochastic multi-mode problem (Herroelen and Leus 2005a). The literature on the stochastic project scheduling problem is sparse (for a detailed discussion, see Chapter 9 in Demeulemeester and Herroelen, 2002).

Stochastic Resource Constrained Project Scheduling

Due to the combination of random task durations and limited resources, the SRCPSP can be classified as a stochastic dynamic optimization problem. Stochastic project scheduling does not create a baseline schedule but views the problem of scheduling projects under precedence and resource constraints as a multi-stage decision process which uses so-called scheduling policies (Stork 2000). A policy may be seen as a dynamic decision process that defines which jobs are started at certain decision times t, based on the observed past up to t. Since it is commonly believed that the class of all policies is computationally intractable, different subclasses of policies have been considered in the literature (Igelmund and Radermacher 1983a; Igelmund and Radermacher 1983b; Möhring, Radermacher et al. 1984; Möhring, Radermacher et al. 1985; Radermacher 1985). Möhring and Radermacher (1985) have contributed an illustrative survey.

Independently from the work mentioned above, scheduling policies were also studied with the objective of minimizing the expected project duration over a class of policies by developing the corresponding optimization problem in its general form as a multi-stage stochastic programming problem (Fernandez, Armacost et al. 1996; Pet-Edwards, Selim et al. 1998; Fernandez, Armacost et al. 1998b). There are only a few computational publications on the SRCPSP. Branch and Bound methods have been studied by Iglemund and Radermacher (1983a) and Stork (2000, 2001). There are very few heuristic algorithms for the stochastic RCPSP (Pet-Edwards 1996; Tsai and Gemmill 1996; Golenko-Ginzburg and Gonik 1997; Tsai and Gemmill 1998).

Stochastic Activity Interruptions

The SRCP with STI Problem (Stochastic Resource Constrained Project Scheduling Problem with Stochastic Task Insertions) has received little attention in the literature. This problem seeks to provide a solution for projects that have some activities that may or may not occur with some level of probability. These tasks are referred to as “unplanned” work. Because the occurrence of these tasks is uncertain, the problem can be classified as a stochastic problem. All other task data (such as duration, resources, and cost) are deterministic. The stochastically occurring tasks can have a significant impact on various project metrics including project completion time, task start times and task sequencing.

As noted in Selim (2002) the SRCP with STI problem is related to other scheduling applications. One research effort resulted in a polynomial activity insertion algorithm to reschedule an existing schedule when an unplanned activity occurred (Artigues and Roubellat 1998). This is not an effective method for managing large projects with a high percentage of potential unplanned work. The SRCPSP with stochastic activity interruptions was studied by Valls, Laguna et al. 1999. Their research deals with the RCSP where some activities may be interrupted for an uncertain amount of time. Deterministic activities had a known duration and could not be interrupted and the stochastic activities were those that could be interrupted for an uncertain amount of time and resumed later. The authors developed a scenario-based approach. The scenarios are generated by specifying three time estimates both for the interruption and for the second part of each stochastic activity. The solution algorithm is a hybrid algorithm based on the scatter search methodology.

The first known research effort into the SRCP with STI which sought to develop robustness schedules based on newly developed robustness measures was conducted by Selim 2002. The current research expands upon the groundwork laid in Selim (2002) and is discussed further in Chapter Four.

Stochastic Discrete Time/Cost Trade-off Problem

The literature on the stochastic version of the discrete time/cost trade-off problem is virtually void (Herroelen and Leus 2005a). Wollmer (1985) described stochastic programming models for solving a stochastic version of the deterministic linear time/cost trade-off problem for activity-on-the-arc networks but offers no computational results. Gutjahr et al. (2000)

considered beta-distributed activity durations and crashing measures that can be used to reduce the expected activity duration at an extra cost. They presented a stochastic branch-and-bound procedure to minimize the expected overall project loss.

Multi-mode Trade-off Problems in Stochastic Networks

The literature on this problem is virtually void although a few heuristic procedures have been suggested (Golenko-Ginzburg and Gonik 1998; Jørgenson 1999; Elmaghraby 2000)

Fuzzy Project Scheduling

When historical data is unavailable, the probability distributions for activity durations are unknown and therefore must be estimated by human experts. These estimates can be vague and imprecise rather than uncertain. In these situations advocates of fuzzy set scheduling recommend the use of fuzzy numbers for modeling activity durations rather than stochastic variables. Instead of probability distributions, these quantities make use of membership functions, based on possibility theory (Herroelen and Leus 2005a). The literature on fuzzy resource-constrained project scheduling is still in its infancy (Hapke and Slowinski 1996; Hapke, Jaskievicz et al. 1999; Wang 1999; Hapke and Slowinski 2000; Özdamar and Alanya 2000; Wang 2002; Wang 2004)

Proactive (Robust) Project Scheduling

As Herroelen and Leus (2005a) pointed out, numerous techniques for proactive (robust) scheduling have recently been published primarily in the machine scheduling literature (Daniels and Kouvelis 1995; Daniels and Carrillo 1997; Kouvelis, Daniels et al. 2000; Davenport and Beck 2002). The goal of proactive scheduling is to factor in uncertainty when generating the original predictive schedule. The consideration of uncertainty information is used to make the predictive schedule more robust. A robust schedule as been defined as:

- One that is "likely to remain valid under a wide variety of disturbances" (Leon, Wu et al. 1994).
- One where the "violation of the assumptions upon which it is built are of no or little consequence" (Le Pape 1991)
- "the ability to satisfy performance requirements predictably in an uncertain environment" (Le Pape 1991)
- "the performance of a schedule when disruptions, such as the occurrence of a stochastic task occur" (Selim 2002)

There are several approaches to proactive scheduling: redundancy-based techniques, robust machine scheduling techniques, robust project scheduling techniques and contingent scheduling (multiple schedules). A brief overview of each is provided below.

Redundancy-based Techniques

The main characteristic of the work reviewed in this section is the reservation of extra time and/or resources so that unexpected events during execution can be dealt with by using some of this "extra" time and resource (Ghosh, Melhem et al. 1995; Ghosh 1996). Pure resource redundancy is unrealistic as the cost of providing redundant resources and/or running the same task multiple times in parallel is prohibitive. Time redundancy may be relevant, but unfortunately in the competitive world of contract negotiations, extensive time to completion projections may result in the loss of the contract award.

Temporal protection extends the activity durations to account for the uncertainty in resource availability and execution (Gao 1995). The "protected" duration of each activity equals its original duration augmented with the duration of the breakdowns that are expected to occur during activity execution, based on breakdown statistics for the performing resources (mean time to failure, mean time to repair, which makes this approach less applicable in a project setting, where most resources are human beings). The baseline schedule is then obtained by solving the scheduling problem with protected durations (Herroelen and Leus 2005a). An extension of this approach does not incorporate slack into individual activity durations, but instead concentrates aggregated activity slack into the most vulnerable areas of the schedule (Davenport, Gefflot et al. 2001). The problems of minimizing the maximum lateness in a job shop subject to machine breakdowns and minimizing the total tardiness on a single machine with dynamic job arrival and random breakdowns are studied by Mehta and Uzsoy (1998, 1999). Both insert additional idle time into the predictive schedule to absorb the impact of machine breakdowns. Taveres, Ferreira et al. (1998) studied the risk of a project as a function of the uncertainty of the duration and the cost of each activity and the adopted schedule. They increase the earliest activity start times by the product of the total float of the activity and a float factor and prove that the adapted start times yield a feasible schedule.

Robust Machine Scheduling Techniques

Leon, Wu et al. (1994) developed robustness measures and robust scheduling methods to deal with machine breakdowns and processing time variability where a right-shift control policy is used in case of a disruption to minimize the expected makespan. Daniels and Kouvelis (1995) studied the single machine problem and develop a measurement for regret based on the absolute difference between the total flow time of the actual schedule and the flow time obtained using the optimal processing time rule. This measure is expanded to the two-machine flow shop in Kouvelis, Daniels et al. (2000). Several researchers have applied the minimax and minimax regret objective approaches from decision analysis to obtain schedules that minimize the consequences of the worst case scenario or the difference between the realized schedule and the schedule that would have been obtained with perfect information (Daniels and Carrillo 1997; Kouvelis and Yu 1997; Jensen 2001; Sevaux and Sörensen 2002a; Sevaux and Sörensen 2002b)

Robust Project Scheduling

Herroelen and Leus (2004a) develop mathematical programming models for the generation of stable baseline schedules under the assumption that the proper amount of resources can be acquired if booked in advance based on the pre-schedule and that a single activity disruption (duration increase) may occur during schedule execution. The models are based on the float factor model of Tavares, Ferreira et al. (1998) and the linear programming based heuristic of Mehta and Uzsoy (1998, 1999). They use as a stability measure the expected weighted deviation of the start times in the schedule realized after project execution from those in the pre-schedule. They derive a linear programming model, the dual of which corresponds to a minimum cost network flow problem, which can be solved efficiently. The authors have extended the model to cope with multiple disturbances. They report on very promising computational results obtained on a set of randomly generated test instances. Results obtained on a dataset consisting of 300 instances generated using the problem generator *RanGen* (Demeulemeester, Vanhoucke et al. 2003) demonstrated that the new model outperforms the models of Tavares, Ferreira et. al. (1998) and Mehta and Uzsoy (1998, 1999).

Leus and Herroelen (2004) utilized a so-called resource flow network (Naegler and Schoenherr 1989; Bowers 1995; Artigues and Roubellat 2000) to represent the flow of resources across the activities of a project network. Their research presents a resource allocation model that protects a given baseline schedule against activity duration variability when some advance knowledge about the probability distribution of the activity durations is available. A branch-and-bound algorithm is developed that solves the proposed resource allocation problem.

Contingent Scheduling (Multiple Schedules)

Contingent techniques are based on attempting to anticipate likely disruptive events and generating multiple schedules (or schedule fragments) which optimally respond to anticipated events. This is all done a priori so that at execution time a set of schedules is available. Responding to unexpected (but anticipated) events and execution time simply consists of switching to the schedule that corresponds to the events that have occurred (Davenport and Beck 2002). This approach focuses on flexibility, rather than robustness, and is especially valuable for time-critical reactive scheduling. The concept of a group sequence was proposed by Billaut and Roubellat (1996a) whereby all possible schedules would be generated using an arbitrary choice of the operations inside each group and was studied in the context of a single machine shop (Aloulou, Portmann et al. 2002; Mauguière, Billaut et al. 2002). The concept was also studied in context of multiple renewable resources (Billaut and Roubellat 1996a; Billaut and Roubellat 1996b) and in the multi-mode scheduling context (Artigues, Roubellat et al. 1999; Briand, Despontin et al. 2002).

Sensitivity Analysis

Research on sensitivity analysis has just emerged in the area of machine scheduling (Hall and Posner 2000a; Hall and Posner 2000b; Penz, Rapine et al. 2001). Efforts to seek answers to various types of "what if …" questions in a project setting still need to be initiated (Herroelen and Leus 2005a).

GERT

Stochastic project networks (GERT networks) deal with projects with stochastic evolution structure. The durations of different activities and different executions of one and the same activity are assumed to be independent. A state-of-the-art survey of GERT network scheduling can be found in Neumann 1999. The author considers the resources to be machines and reviews methods for approximately solving single machine, parallel machine, job shop and flow shop problems with GERT network precedence constraints. The literature on RCPS with GERT networks, however, is virtually void.

Chapter Three describes the Critical Chain and Buffer Management approach as proposed by Goldratt (1997) and presents a summary of the critiques that have been offered by other researchers who have investigated the model.

CHAPTER THREE: INTRODUCTION TO THE BUFFER APPROACH

This chapter begins with a description of the theory and practice of the Critical Chain Scheduling and Buffer Management method (CC/BM) as proposed by Goldratt (1997) and concludes with a description of the merits and pitfalls of critical chain scheduling as identified by other researchers. The CC/BM method can be classified as a predictive-reactive scheduling approach that addresses the SRCP problem.

Critical Chain Scheduling and Buffer Management Overview

Critical Chain Scheduling and Buffer Management (Goldratt 1997) aims at developing a sound schedule, using buffer management, in order to avoid project overruns. The methodology is not well defined in the sense that it does not provide precise definitions for some project entities and scenarios. Rather, it gives a heuristic framework and guidelines for project managers on how to plan, schedule, and control their projects, and it is up to the user of the method to complete the details. CC/BM starts from the basic observation that the problems common to all projects are the high probability of (a) budget overruns, (b) time overruns, and (c) compromising the content. CC/BM is to be deployed as a project management strategy to avoid project delays caused by Parkinson's Law (work expands to fill the time allowed (Parkinson 1957; Gutierrez and Kouvelis 1991)) while protecting for Murphy's Law (uncertainty involved in the work). CC/BM tries to minimize the impact of Parkinson's Law by building the schedule with target duration estimates based on a 50% confidence level, by eliminating task due dates and milestones, and by eliminating multitasking (Herroelen and Leus 2001a).

CC/BM's starting point is a list of tasks along with their duration estimates and dependencies. The first step consists of developing an initial schedule for project tasks. This is done while taking into account the dependencies among the tasks (as reflected in the project network) and the availability of resources. Because at least some of the resources have limited availability, the resulting schedule is likely to be longer than the schedule obtained with the basic Critical Path Method algorithm, as critical activities are delayed while waiting for the resources they require.

At this point, CC/BM identifies the critical chain as the set of tasks that results in the longest path to project completion taking into account both precedence and resource dependencies (Goldratt 1997). Resource conflicts, if they do occur, are resolved by moving tasks earlier in time (Newbold 1998). If more than one critical chain appears in the schedule, the advice is to "just pick one" and buffer the others (Herroelen and Leus 2001a). The critical chain yields the expected project completion date. Resources required by the tasks on the critical chain are defined as critical resources. So far, CC/BM is the same as conventional project management except for the terminology "critical chain," which would otherwise be called the "resource-leveled critical path." The next step in CC/BM planning consists of recalculating the project schedule based on shortened task duration estimates. The rational for shortening the original duration estimates is as follows:

- All tasks in the project are subject to some degree of uncertainty;
- When asked to provide an estimate of the duration, the task owner adds a safety margin in order to be almost certain of completing the task on time. This means that, in general, task durations are overestimated;

- In most cases, the task will not require the entire amount of safety margin and should be completed sooner than scheduled;
- Because the safety margin is internal to the task, if it is not needed, it is wasted. The resources for the next task are not available until the scheduled time. Therefore, when it becomes obvious that the buffer is unnecessary, the task owner will use the buffer time anyway, because there is little incentive to finish early. On the other hand, any delays in the completion of tasks on the critical chain propagate to the successor tasks. Thus, gains are lost, delays are passed on in full, and the project is likely to finish late even if, on average, there are enough buffers hidden in the tasks.

CC/BM states that original duration estimates are such that the likelihood of completion is 95%, and that they should be reduced to the point where the likelihood of completion is 50%. The difference between the project duration based on new estimates and the original project duration is called the project buffer and should be displayed on the project Gantt chart as a separate task. Figure 1 illustrates the relationships between the original schedule and the CC/BM schedule based on the shortened task durations (Raz, Barnes et al. 2003).

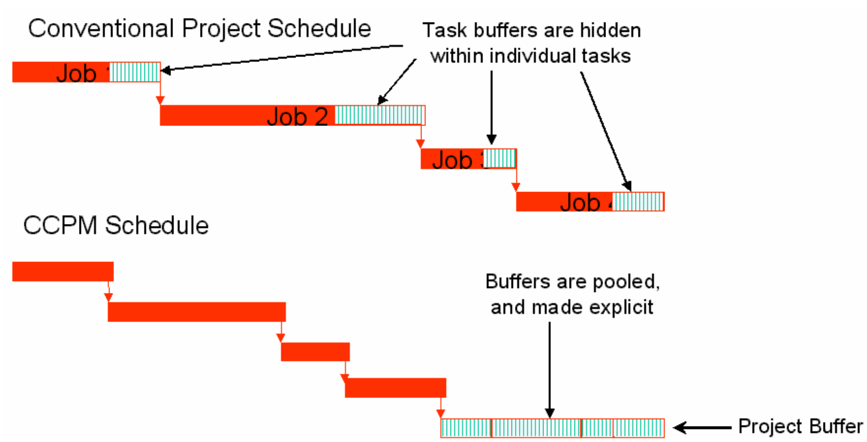

Figure 1: Conventional schedule and CC/BM schedule with time buffers shown explicitly (Raz, Barnes et al. 2003)

The buffers, which were previously hidden in each task, have been made explicit and pooled. This pooled buffer is called the project buffer. Note that by calculating the project buffer, the total duration of the project did not increase. Under CC/BM, the project buffer is considered part of the project and, as such, must be scheduled and assigned resources. A Gantt chart showing the project buffer serves to communicate the inherent uncertainty in the project as opposed to a conventional Gantt chart that presents a spurious air of certainty.

It is improbable that all the critical chain tasks will exceed their 50% likelihood duration estimates. Under the assumption of statistical independence, about half of the tasks will exceed the 50% mark, while the other half will be completed at less than 50%. By pooling together the safety margins of the individual tasks, the protection against uncertainty is improved, so CC/BM suggests that the combined project buffer can be less than the sum of the safety margins of the individual tasks. This argument is supported by statistical theory that states that the standard deviation of the sum of a number of mutually independent random variables (in this case, the actual durations of the tasks on the path) is less than the sum of the individual standard deviations. Although the assumption of statistical independence of task durations is questionable, this justifies reducing the overall duration of the project. In practice, it may be easier to gain task owners' acceptance of pooling their individual task buffers if the total is not reduced.

The same process of making safety margins explicit and pooling them can be applied to non-critical paths. As before, the safety margin in each task is identified, taken out, and pooled at the end of the path. Because this buffer is placed where the path feeds back into the critical chain path, it is called a feeding buffer. Figure 2 (Raz, Barnes et al. 2003) shows a simple project network where a feeding buffer has been identified. According to CC/BM, a feeding buffer represents the extent of the critical chain's protection against the uncertainty in the feeding noncritical chain, and its size may be adjusted as desired. Once the size of the feeding buffer has been determined, if there is still some slack on the feeding chain, CC/BM prescribes that the task be scheduled as late as possible. This is justified on the basis that it reduces waste of time and work in process on the noncritical tasks while preserving the desired degree of protection of the critical chain.

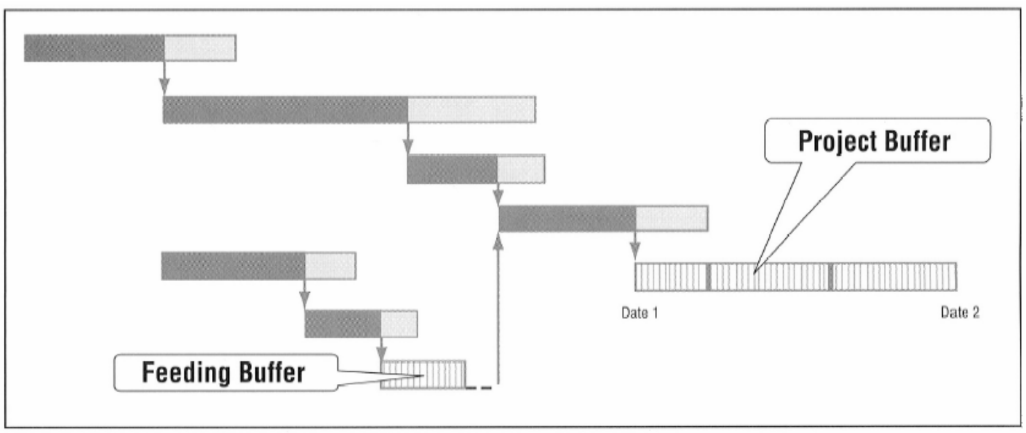

Figure 2: Project network with feeding buffer identified (Raz, Barnes, et al. 2003)

The third type of buffer used by CC/BM is called a resource buffer, which is a virtual task inserted prior to critical chain tasks that require critical resources. Its purpose is to issue a signal to the critical resource that a critical chain task to which they are assigned is due to start shortly. According to CC/BM, this wake-up call will cause the critical resource to wrap up any noncritical work and be ready to start work on the critical chain task as soon as its predecessors are completed. The resource buffer does not actually consume any resource, and it adds neither time nor cost to the project.

At this point, CC/BM has created a new project schedule consisting of the original tasks with reduced durations and various types of buffers: the project buffer, the feeding buffer, and the resource buffer. For project plan execution, CC/BM prescribes the following principles:

1. Resources working on critical chain tasks are expected to work continuously on a single task at a time. They do not work on several tasks in parallel or suspend their critical tasks to do other work.
2. Resources are to complete the task assigned as soon as possible, regardless of scheduled dates.
3. If the task is completed ahead of schedule, work on its successor is to begin immediately. If the task successor utilizes a critical resource for which a resource buffer has been defined, advance warning is provided to that resource at the point in time where the resource buffer begins;
4. If the task is completed past its planned completion date, as shown on the CC/BM schedule, this is no reason for immediate concern, as the buffer will absorb the delay.

The execution of the project is managed through the use of buffer management. As activities are completed, managers keep track of how much of the buffers are consumed. As long as there is some predetermined proportion of the buffer remaining, everything is assumed to go well. If activity variation consumes a buffer by a certain amount, a warning is raised. If it deteriorates past a critical point, corrective action should be taken.

CC/BM Critique

Subsequent to the publication of Goldratt's book *Critical Chain* in 1997 (Goldratt 1997), recent books (Newbold 1998; Leach 2000), articles (Cabanis-Brewin 1999; Patrick 1999; Pinto 1999; Globerson 2000; Maylor 2000; Rand 2000), Web pages (Focus 5 Systems Ltd.; Focused Performance; Product Development Institute 1999), book reviews (Elton and Roe 1998; McKay and Morton 1998; Rand 1998; Schulyer 1998), and letters to the editor in the *Project Management Journal* and *PM Network* have been written on the subject. Specific software packages based on the critical chain scheduling concepts have recently been developed (ProChain Solutions Inc. 1999; Thru-Put Technologies Inc. 1999; Scitor Corporation 2000). Internet discussion groups (see, for example, http://www.prochain.com/ and the Yahoo group http://www.groups.yahoo.com/group/criticalchain) focus on critical chain scheduling issues. Critical chain scheduling principles have been adopted by a growing number of companies. The majority of the writings consider CC/BM as the most important breakthrough in the history of project management. Critical views risk being pushed into a minority position, mostly deal with global project management issues and do not seem to address the real essence of the scheduling issues involved (Herroelen and Leus 2001a; Herroelen, Leus et al. 2002).

While real-world applications by companies such as Lucent Technologies, Lord Corporation, and Harris Semiconductor have been described to demonstrate the effectiveness of the CC/BM approach (Leach 1999; Umble and Umble 2000; Harris 2001; Lord Corporation 2001), other sources (Zalmenson and Zinman 2000; Zalmenson and Zinman 2001; Herroelen and Leus 2001a; Herroelen, Leus et al. 2002) alert the reader to serious drawbacks and implementation failures or at least claim CC/BM is not at all innovative (Raz and Marshall 1996; Wilkens 2000; Trietsch 2005a; Trietsch 2005b)

Several researchers have conducted studies to define a more precise approach to buffer sizing (Newbold 1998; Hoel and Taylor 1999; Leach 2003; Trietsch 2005b) and many have recognized the need for a more structured approach to buffer management (Leach 1999; Rand 2000; Raz, Barnes et al. 2003; Trietsch 2005b). The working principles of the CC/BM method have been validated through a full factorial computational experiment using the 110 Patterson test problems (Patterson 1984) by Herroelen and Leus (2001a). Contrary to CC/BM belief, they reach the conclusion that (Herroelen and Leus, 2004b, page 1605):

- "updating the baseline schedule and the critical chain at each decision point provides the best intermediate estimates of the final project duration and yields the smallest final project duration
- using a clever project scheduling mechanism such as branch-and-bound has a beneficiary effect on the final makespan, the percentage deviation from the optimal final makespan obtainable if information would be perfect, and the work-in-progress
- using the 50% rule for buffer sizing may lead to a serious overestimation of the project buffer size
- keeping the critical chain activities in series is harmful to the final project makespan"

Herroelen and Leus (2001) also point out that CC/BM correctly argues that the baseline schedule must be constructed in the presence of uncertainty. Instead of solving a stochastic RCPSP however, CC/BM generates a baseline schedule by solving the deterministic RCPSP and subsequently makes the schedule robust through the insertion of various types of buffers. Herroelen, Leus et al. (2002) have studied the practical implications of the scheduling procedure and have warned against the serious oversimplifications of the approach.

Research related to the use of buffers in project scheduling and management is virtually void. The machine scheduling literature approaches this concept from the idea of time and resource redundancy (Gao 1995; Ghosh, Melhem et al. 1995; Ghosh 1996; Mehta and Uzsoy 1998; Tavares, Ferreira et al. 1998; Mehta and Uzsoy 1999; Davenport, Gefflot et al. 2001). The research on the use of buffer techniques as a method to manage uncertainty in project scheduling environments is in the burn-in phase. The primary research efforts have been conducted at the Katholieke University in Leuven, Belgium in a series of research reports (Van de Vonder, Demeulemeester et al. 2004a; Van de Vonder, Demeulemeester et al. 2004b; Van de Vonder, Demeulemeester et al. 2005).

Van de Vonder et al. (2004a) addressed the potential trade-off between the quality robustness (measured in terms of the project duration) and solution robustness (stability, measured in terms of the deviation between the planned and realized start time of the projected schedule). A heuristic procedure for generating buffered baseline schedules for projects *with ample renewable resource availability* is suggested. This procedure is called the adapted float factor heuristic (ADFF) and is an adaptation of the float factor model that was originally introduced by Tavares, Ferreira et al. (1998). When applied to a resource-constrained project, ADFF scatters intermediate time buffers throughout a baseline schedule but does not prohibit resource conflicts from occurring because neither the early start schedule nor the late start schedule are guaranteed to be resource feasible. The main conclusion of this paper is that the expected difference in makespan performance between makespan protecting schedules and solution robust schedules tends to disappear for some projects. Where this is the case, a solution robust schedule will most likely be preferred because of the considerably lower stability cost.

Van de Vonder et al. (2004b) proposed a heuristic algorithm to *protect the starting times of intermediate activities* when multiple activity disruptions occur by adding intermediate buffers to a minimal duration RCPSP. In this study, the reactive policy of preserving the resource flows between activities whenever a disruption occurred was implemented. An extensive simulation experiment was conducted to investigate the trade-off between quality robustness (measured in terms of project duration) and solution robustness (stability). The advantages of both scheduling approaches depend highly on the project characteristics and especially on the relative importance of timely project completion compared to the importance of timely completion of the intermediate activities. The paradoxical fact that makespan protecting schedules were shown to be hard to defend when makespan becomes very important, was the main conclusion of the paper.

Van de Vonder et al. (2005) introduced multiple algorithms to include time buffers *in a given schedule* while a predefined project due date remains respected. Multiple efficient heuristic and meta-heuristic procedures are proposed to allocate buffers throughout the schedule. An extensive simulation-based analysis of the performance of the algorithms is given. The results of the study show that the heuristic which utilizes information on activity weights and activity duration variability for the buffer allocation process provides the best results.

Although the CC/BM approach does have theoretical limitations, the concept of buffer insertion and management heuristics as a means to manage the uncertainty in project environments does provide an interesting potential for future research. The potential for utilizing buffers in SRCP with STI has not been explored explicitly anywhere in the literature, although the research conducted in Selim (2002) provided an initial look at extreme buffering methodologies. Chapter Four provides a description of how the partial buffer concept can be applied to SRCP with STI.

CHAPTER FOUR: APPLYING BUFFERS TO THE SRCP WITH STI

The purpose of this research is to provide project managers with an effective buffer sizing policy to effectively schedule SRCP with STI problems of varying complexity factors with the goal of improving project performance metrics related to project makespan and stability.

As described in Chapter Three, the buffer insertion and management concept is relatively new to the project scheduling literature and is receiving increasing interest among practitioners as a means to manage the uncertainty inherent in a project scheduling environment. To date, the project scheduling literature has only utilized the buffer concept to address variability in individual task durations (Herroelen and Leus 2001a; Herroelen, Leus et al. 2002; Van de Vonder, Demeulemeester et al. 2004a; Van de Vonder, Demeulemeester et al. 2004b; Herroelen and Leus 2005b). The SRCP with STI problem has also received very little attention in the project scheduling literature and the idea of utilizing buffers to manage task occurrence uncertainty has never been formally addressed in the literature. The experiment conducted in Selim (2002) was the first published document that addressed the need for robustness measures for the SRCP with STI problem. A byproduct of the Selim (2002) research, although not formally stated, was an initial study into the application of the buffer concept, utilizing extreme buffer sizes, to the SRCP with STI problem. There are many opportunities for additional research into the SRCP with STI problem utilizing partial buffers to manage task occurrence uncertainty. This chapter will review the objectives and findings of Selim (2002) and offer a description of the contributions this research provides.

The primary objective of Selim (2002) was to develop a set of robustness measures for the SRCP with STI problem so that project managers could better evaluate the quality of a schedule. In addition, a study was conducted to determine the effects of various factors (network, resource, stochastic and scheduling methods) on the robustness of a schedule. Six robustness measures were developed, two were duration-related and four were re-sequencing related. All of the measures involved calculating differences between performance results obtained by various scheduling methods and policies: base schedule (initial schedule), modified base schedule, and perfect knowledge schedule.

Selim (2002) defined two types of base schedules dependent on whether or not all or none of the stochastically occurring tasks were scheduled. A pessimistic base schedule results when all stochastically occurring tasks are scheduled and an optimistic base schedule results when none of the stochastically occurring tasks are scheduled. Although it was not specifically stated in the research, the pessimistic schedule can be equated to a full or 100% extreme buffering approach and the optimistic schedule can be equated to a zero-buffering extreme approach. The modified base schedule is the schedule that results after a right-shift or left-shift control policy has been applied to the optimistic or pessimistic schedule, respectively. The modified base schedule results in the actual task start and completion times. The final type of schedule defined in Selim (2002) is the perfect knowledge schedule which is the schedule that would have been generated had all of the variables been known a priori. It is the optimized version of the modified base schedule.

The robustness measures that were developed in Selim (2002) included two duration measures which calculated the project duration differences between 1) the modified base to perfect knowledge schedule and 2) the modified base to base schedule. The four re-sequencing related measures resulted in metrics to calculate 1) a count of changed task start times in the modified base schedule as compared to the perfect knowledge schedule 2) a count of the number of tasks with changed preceding tasks in the modified base schedule as compared to the perfect knowledge schedule 3) a count of the total number of tasks in the modified base schedule that had additional preceding tasks as compared to the perfect knowledge schedule and 4) a measure to determine the total number of tasks for which at least one preceding task in the perfect knowledge schedule was no longer a preceding task in the modified base and the task had at least one new preceding task (Selim 2002).

The twenty networks utilized in Selim (2002) consisted of projects of 30 tasks each with two resource types with a maximum of ten units of each type available. Parameters related to the network topology, resources, scheduling methodology, stochasticity levels and stochasticity locations were varied to determine the effectiveness of the initial approach (pessimistic or optimistic) utilized to manage the stochastically occurring tasks. A thorough experimental analysis was conducted and the final summary results showed that for both low and high stochasticity levels, the pessimistic scheduling method results in a more robust schedule in terms of the defined duration and re-sequencing related robustness measures. Furthermore, when the level of stochasticity was high, it was even more important to utilize the pessimistic baseline scheduling approach to improve the robustness measures. The results also indicated that when the stochastic tasks occur early in the schedule as opposed to late in the schedule, the schedule is more robust. Project schedulers therefore need to pay close attention to stochastically occurring tasks in the later part of the schedule. Results from the resource and network parameter study indicated that the higher the level of resource utilization, the less robust the schedule. Therefore, a project scheduler should attempt to bring in additional resources to make the schedule more robust. Finally, the fewer precedence constraints contained in a network, the less robust the schedule will be (Selim 2002).

Selim (2002) noted that the initial baseline scheduling approaches utilized in the research involved extreme approaches: pessimistic or optimistic. While the pessimistic approach provided better robustness measures, a project scheduler may not have the time, cost, or physical resources to schedule all of the stochastically occurring tasks. Furthermore, as project size increases and the number of stochastically occurring tasks increases, the pessimistic approach might result in project schedules that are uncompetitive and unacceptable to the customer. One potential solution to this problem is to incorporate a partial buffering concept into the initial baseline schedule. In addition, a project scheduler might be willing to trade a reduction in duration robustness measure performance for an improvement in stability related measures or vice versa.

This research expands upon the groundwork laid in Selim (2002) by investigating the types of improvements that can be made in project makespan and stability metrics when a partial buffering scheme, rather than an extreme buffering scheme, is utilized to manage the SRCP with STI. Several partial buffering plans were included in this research and will be described in detail in Chapter Six. Specifically, this research will address the following objectives:

1. Determine if a partial buffering approach results in project duration and stability metric improvements when compared to the optimistic and pessimistic extreme buffer scheduling methods.
2. Determine if a fixed buffer size or a variable buffer size, which incorporates knowledge of the stochasticity of the networks, produces the most improvement in project metric performance.

3. Determine what, if any, impact the following factors have on the buffer sizing recommendation: network factors, resource factors, stochasticity level and stochasticity location.

Additional contributions of this research are:

1. New project stability metrics that measure the change in task start times between the base schedule, the modified schedule and the perfect knowledge schedule.
2. New buffer sizing rules designed to specifically address the SRCP with STI.

Chapter Five presents the research factors and experimental design necessary to satisfy the research objectives listed above.

CHAPTER FIVE: RESEARCH FACTORS

The major objectives of this research are to demonstrate the effectiveness of applying a partial buffering policy to the SRCP with STI problem in terms of improvements in project metric performance, as reflected by results obtained from the duration robustness measures developed in Selim (2002) and new robustness measures introduced in this research. The results of the experiment will provide project schedulers with a strategy for scheduling a variety of SRCP with STI problems of varying network factors, resource parameters, stochasticity levels and stochasticity locations.

The factors under investigation in this study are:

1. Network Factors
2. Resource Factors
3. Stochasticity Location
4. Stochasticity Level
5. Buffer Sizing Method

A description of the factors and experimental process are discussed in this chapter. The chapter concludes with a description of the experimental design.

This research expands upon the groundwork laid in Selim (2002). In order to quantify the improvements in project metric performance that can be achieved with partial buffering, the networks studied in Selim (2002) will be replicated using the same network generator chosen by Selim, RanGen (Demeulemeester, Vanhoucke et al. 2003). The RanGen data input format requirements can be found in Appendix A.

Network Generation - RanGen

RanGen is a relatively new network generator that generates activity-on-node networks with preset vales of network topology and resource parameters. The developers of RanGen argue that previous network generators are more limited in terms of the network and resource parameters that can be used and that RanGen allows for the study of problem instances spanning a full range of problem complexity factors (Demeulemeester, Vanhoucke et al. 2003). RanGen allows the user to specify the network size as well as network parameters for the Order Strength (OS) and Complexity Index (CI). In addition, resource parameters such as the Resource Factor (RF) and Resource Constrainedness (RC) can also be specified by the user. The networks utilized in Selim (2002) were generated utilizing the RanGen program and will be replicated for comparative analysis with the partial buffering approaches introduced in this research.

Network Topology Measures

The network parameters utilized in RanGen are user-specified values for Order Strength (OS) and the network Complexity Index (CI). OS is defined as the number of precedence relations divided by the theoretical maximum number of precedence relations (Mastor 1970). CI is defined as: "the minimum number of node reductions sufficient (along with series and parallel reductions) to reduce a two-terminal acyclic network to a single edge" (De Reyck and Herroelen 1996). Guidelines for realistic combination values of OS and CI have been obtained by conducting a full factorial experiment and can be found in (Demeulemeester, Vanhoucke et al. 2003).

Resource Measures

RanGen also utilizes several resource measures including: a resource factor (RF), and resource constrainedness (RC). The RF measures the average amount of resource types requested by each activity. An RF=1 means that each activity requests all resources (Pascoe 1966). RC is defined as the availability of a resource divided by the average amount of that resource (Patterson 1976; De Reyck and Herroelen 1996).

Table 1 provides a summary of the network characteristics developed by Selim (2002) and replicated for this research. All of the networks investigated in this research contained thirty tasks and a start and end task. Each network also was defined to contain two resource types with a maximum of ten resources per type.

Table 1:

Levels of network and resource parameters (Selim 2002)

	Resource Parameter			
Network Parameter	Low	Network No.	High	Network No.
Low	OS=.40 CI=13 RF = .40, .45, .50 RC = .25	1004 1010 1015 1020 1028	OS=.40 CI=13 RF = .75, .80, .85 RC = .75	1102 1105 1112 1119 1127
High	OS=.85 CI=21 RF = .40, .45, .50 RC = .25	1200 1201 1212 1222 1225	OS=.85 CI=21 RF = .75, .80, .85 RC = .75	1300 1304 1308 1314 1325

Stochastic Network Factors

The second set of factors under investigation relate to the level of stochasticity found in the network and the location within the network that the stochastic tasks occur. These factors were defined and analyzed in Selim (2002) and will be replicated in this research.

Location of Stochasticity

The location of stochasticity (LS) refers to the position within the network where the stochastic tasks occur. For this research, the locations defined in Selim (2002) will be adopted. The location of stochasticity was defined as “early” if the stochastic tasks occur within the first half of the pessimistic schedule and “late” if the stochastic tasks occur within the second half of the pessimistic schedule (Selim 2002).

Level of Stochasticity

The level of stochasticity (LVS) was defined in Selim (2002) to be dependent upon the number of stochastic tasks that actually do occur versus the number of stochastic tasks that potentially might occur. In this research, the project networks were defined to contain a total of thirty activities. Selim (2002) defines a low level of stochasticity to be where eight of the thirty tasks have the potential to occur stochastically. A high level of stochasticity was defined to be when sixteen of the thirty tasks might occur stochastically.

Selim (2002) performed two separate experiments to isolate the level of stochasticity factor. Experiment one investigated the low stochasticity level and experiment two investigated the high stochasticity level. A similar approach will be taken in this research for comparative purposes.

Buffer Sizing Approach

As described previously, the scheduling methods referenced in Selim (2002) were extreme buffer sizing approaches, although they were not specifically identified as such. The pessimistic method is an extreme buffering approach that allocates 100% of the task time for all tasks that were identified as potentially occurring stochastic tasks. The optimistic approach implemented the opposite extreme measure where no time was allocated for any task that was identified to be potentially stochastically occurring. Selim (2002) used the "left shift" rescheduling policy on the pessimistic baseline schedule when stochastic tasks did not occur and the "right-shift" policy on the optimistic baseline schedule when stochastic tasks did not occur. For both rescheduling policies, the protocol was to maintain the sequence of tasks as much as possible while keeping track of precedence and resource constraints.

This research introduces the concept of partial buffering to the SRCP with STI with the objective of providing a quantifiable measure of project stability and duration metric performance improvement. A total of seven partial buffering approaches are developed to form a range of partial buffer sizes. The first three partial buffering measures are based on a fixed percentage of task time; 10%, 30% and 50% respectively. The remaining four partial buffering schemes were developed for this research to determine the effects and potential advantages of allocating varying buffer portions to each stochastic task depending upon factors such as the location of the task in the project schedule and knowledge of the characteristics of the stochasticity. The partial buffering rules are defined and discussed in detail in the following chapter.

Phased Experiment Description

The current research is conducted in two phases. The objective of the first phase of the experimental process is to serve as a screening process to determine which of the seven partial buffering approaches are the most promising in terms of project metric improvements. All seven partial buffering schemes were utilized to generate base schedules similar to the base pessimistic and optimistic schedules developed in Selim (2002). It should be noted that the base schedules developed utilizing a partial buffering approach result in infeasible baseline schedules as opposed to the feasible base schedules resulting from the Selim (2002) pessimistic and optimistic scheduling approaches. This means that, in theory, if all of the potential stochastic tasks occur, the pessimistic schedule could be implemented as scheduled and if none of the potential stochastic tasks occur, the optimistic schedule could be implemented as scheduled. The partially buffered base schedule would require some type of rescheduling policy in either all-inclusive stochastic task occurrence or non-occurrence situation. The experiment conducted in Selim (2002), however, defined that only half of the potentially occurring stochastic tasks would actually occur. This was done to evaluate the robustness of the pessimistic scheduling approach as opposed to the optimistic scheduling approach when dealing with the SRCP with STI.

Given the inherent uncertainty in the project scheduling environment as described in Chapter Two, a project manager can expect to make modifications to the baseline schedule. The objective of this research is to minimize the modifications required to transition from the baseline schedule (infeasible or feasible) to the modified (or “as-run” schedule) by utilizing a partial buffering approach. The initial screening experiment is a comparison between the project duration and stability metrics of all seven partial buffering rules to the extreme buffering schedules of Selim (2002). The objective of the screening process is to determine the partial buffering approaches that provide the most promise in terms of improving project metric performance when comparing the baseline schedule to the perfect knowledge schedules generated in Selim (2002). The initial phase of the experiment is discussed in detail in Chapter Six. Based on the results of the initial screening experiment, the partial buffer sizing rules that performed the best were used in a more detailed analysis in which the left shift and/or right shift rescheduling policies were implemented to generate the modified baseline schedules.

Experimental Design

The experimental design was set up similar to Selim (2002). For both phases of the experiment, in order to accurately compare the project metrics, two separate experiments were conducted: one for the low level of stochasticity and one for the high level of stochasticity. For the low level of stochasticity, there were a total of eight potential stochastic tasks. For the high level of stochasticity, there were a total of sixteen potential stochastic tasks Selim (2002). A total of five factors were defined for analysis:

1. Network Factors
2. Resource Factors
3. Stochasticity Location
4. Stochasticity Level
5. Partial Buffer Size

The first three factors were varied on two levels, resulting in 2^3 runs (or 8 runs) per experiment and are defined in Table 2. The experiment was conducted seven times, once for each of the 10%, 30%, 50%, JG3, JG4, JG5 and JG6 partial buffer sizing rules, respectively.

Table 2: Design matrix for the experiments

Experiment 1: Low Stochasticity Level				Experiment 2: High Stochasticity Level			
Run No.	**Network**	**Resource**	**Location**	**Run No.**	**Network**	**Resource**	**Location**
1	L	L	E	1	L	L	E
2	H	L	E	2	H	L	E
3	L	H	E	3	L	H	E
4	H	H	E	4	H	H	E
5	L	L	L	5	L	L	L
6	H	L	L	6	H	L	L
7	L	H	L	7	L	H	L
8	H	H	L	8	H	H	L
Network: L is Low, H is High							
Resource: L is Low, H is High							
Location: E is Early, L is Late							

The experimental process and the results of the phase one experiment are presented in Chapter Six.

CHAPTER SIX: EXPERIMENTAL PROCESS AND PHASE ONE RESULTS

The objective of this research is to provide project managers with a buffer sizing methodology to improve project duration and stability metric performance. Network factors, resource factors and stochasticity factors, as defined in Selim (2002) were used to analyze the performance improvements that can be achieved by utilizing a partial buffering approach as opposed to the extreme optimistic and pessimistic approaches. The specific objectives of this research are:

1. Determine if a partial buffering approach results in project duration and stability metric improvements when compared to the optimistic and pessimistic extreme buffer scheduling methods.
2. Determine if a fixed buffer size or a variable buffer size, which incorporates knowledge of the stochasticity of the networks, produces the most improvement in project metric performance.
3. Determine what, if any, impact the following factors have on the buffer sizing recommendation: network factors, resource factors, stochasticity level and stochasticity location.

Additional contributions of this research are:

1. New project stability metrics that measure the change in task start times between the base schedule, the modified schedule and the perfect knowledge schedule.
2. New buffer sizing rules designed to specifically address the SRCP with STI.

Experimental Process

The first phase of this research involves replicating the networks utilized in Selim (2002) utilizing the same network factors, stochastic factors, and scheduling methods. The concept of partial buffering was then applied to these networks as a means to compare improvements in project metric performance as compared with the results obtained in Selim (2002) and with the new metrics developed in this research. The purpose of this first phase of research is to select the partial buffer sizing methods that produce the greatest project metric improvements when comparing the initial baseline schedule to the perfect knowledge schedule. These partial buffer sizing methods are then utilized in a more detailed study to investigate the performance of the partial buffer techniques when the modified base schedules are created.

Step 1: Replicate the Selim (2002) Networks

The first step is to replicate the networks generated in Selim (2002). The networks were generated with RanGen and then solved optimally with the DH-procedure, resulting in the optimal task sequence (Demeulemeester and Herroelen 1992). The DH procedure is a branch and bound procedure for the multiple RCPSP. The input file format for RanGen can be found in Appendix A and the input file format for the DH-procedure can be found in Appendix B. It should be noted that the RanGen output file format is the input file format required by the DH-procedure.

In each network, a set of tasks was selected to represent the potential stochastic tasks. The selection procedure is defined below.

Stochastic Task Definition

In order to define the tasks which may potentially occur stochastically, Selim (2002) developed a Stochastic Index formula based on task duration and resource requirement characteristics. The formula was defined as follows:

$$SN_m = .5(d_m) + 0.25(r_1) + 0.25(r_2)$$

Where,

SN_m = stochastic number for task m

d_m = duration of activity m

r_1 = total availability of resource 1

r_2 = total availability of resource 2

The Stochastic Number was calculated for each task in each network. Based on the optimal task sequence, as defined by the DH-procedure, the tasks with the highest Stochastic Numbers in the first half of the schedule and the tasks with the highest Stochastic Numbers in the second half of the schedule were defined to be potentially stochastically occurring. For the low level of stochasticity, eight of the thirty tasks were defined to potentially occur stochastically. The first four highest stochasticity numbers in the first and second halves of the schedule were defined to be the stochastic tasks. Similarly, for the high level of stochasticity, the first eight in the first half and the first eight in the second half were defined to be stochastically occurring. Appendix C contains the summary charts for each network including the RanGen output data for: activity duration, task end time, resource utilization, number of successors, successor list, and the calculated stochasticity number and identification of the stochastic tasks. For example the data found in Appendix C for Network 1004 is presented in Figure 3. Note the color scheme used is significant and is consistent throughout all of the figures in this research. Yellow and purple are the eight tasks that have been defined to be potentially stochastically occurring for the low level of stochasticity. The yellow occur in the early part of the schedule and the purple occur in the late part of the schedule. The blue and orange tasks are the additional eight tasks that comprise the sixteen tasks for the high level of stochasticity. The blue occur in the early part of the schedule and the orange occur in the later half of the schedule.

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

				Perfect Knowledge Schedules				Optimistic Schedules																	
				Low Level		High Level																			
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	0	0	0	0	0	0	1	0	5	2	3	5	7	9						
2	6	0	6	6	6	0	6	6	0	0	0	2	3	4	14	10	8	6						5	6.5
3	6	0	6	0	6	0	6	0	0	1	1	3	3.5	2	10	4								9	5.5
4	9	6	15	0	15	0	15	0	0	0	0	4	4.5	3	31	14	6							4	4.5
5	10	0	10	0	10	0	10	0	0	4	2	5	6.5	1	6									3	3.5
6	5	15	20	11	20	0	20	11	0	0	0	6	2.5	7	22	21	20	19	13	12	11			2	3
7	4	0	4	4	4	4	4	4	4	0	0	7	2	8	31	21	20	19	17	16	13	12		31	3
8	1	6	7	7	7	1	7	7	1	0	3	8	1.25	6	20	19	17	16	13	12				6	2.5
9	9	0	9	0	9	0	9	0	0	0	4	9	5.5	7	30	29	28	25	21	18	11			20	2.5
10	2	6	8	8	8	2	8	8	2	3	0	10	1.75	6	31	30	27	25	23	17				12	2.25
11	4	20	24	15	24	4	24	15	4	0	0	11	2	3	27	17	15							7	2
12	3	20	23	14	23	7	23	14	7	1	2	12	2.25	6	30	29	28	26	25	23				11	2
13	7	20	27	18	20	11	20	11	4	3	3	13	5	4	29	27	24	18						22	2
14	2	15	17	8	17	2	17	8	2	0	0	14	1	3	28	19	16							10	1.75
15	4	24	28	19	28	8	28	19	8	1	2	15	2.75	2	23	16								8	1.25
16	8	28	36	27	28	16	28	19	8	0	4	16	5	1	24									14	1
17	7	24	31	22	31	11	31	22	11	0	0	17	3.5	1	26									21	5.75
18	1	27	28	19	21	12	21	12	5	0	2	18	1	1	23									23	5.75
19	8	20	28	19	28	12	20	19	4	0	0	19	4	1	25									13	5
20	4	20	24	15	24	4	24	15	4	2	0	20	2.5	1	23									16	5
21	10	20	30	21	20	14	20	11	4	0	3	21	5.75	1	23									27	5
22	4	20	24	15	24	4	24	15	4	0	0	22	2	1	24									28	4.75
23	9	30	39	30	28	23	28	19	8	0	5	23	5.75	1	32									26	4.5
24	2	36	38	29	30	18	30	21	10	4	0	24	2	1	32									19	4
25	1	28	29	20	29	13	24	20	8	0	0	25	0.5	1	32									17	3.5
26	8	36	44	35	39	24	31	30	11	0	2	26	4.5	1	32									15	2.75
27	8	32	40	31	32	24	24	23	4	3	1	27	5	1	32									24	2
28	9	23	32	23	32	20	23	23	7	0	1	28	4.75	1	32									29	1.75
29	2	27	29	20	25	13	25	16	9	3	0	29	1.75	1	32									18	1
30	1	23	24	15	24	8	24	15	8	0	0	30	0.5	1	32									30	0.5
31	6	15	21	14	21	4	21	14	4	0	0	31	3	1	32									25	0.5
32	0	44	44	35	39	24	31	30	11	0	0	32	0	0											

Figure 3: Network 1004 summary network characteristic data

Pessimistic Schedule

The pessimistic schedule, as defined in Selim (2002), schedules all tasks at 100% of their defined task duration regardless of whether or not the task is a potentially occurring stochastic task. This is a full buffer extreme scheduling approach. The RanGen and DH raw data output values for all twenty networks scheduled using the pessimistic approach can be found in Appendix D. Since all tasks are scheduled at 100% duration, the duration values remain constant for the low and high levels of stochasticity settings.

Optimistic Schedule

The optimistic schedule, as defined in Selim (2002), does not allocate any time to those tasks which have been identified as potentially stochastically occurring. This is the zero buffer extreme scheduling approach. For the low level of stochasticity, eight tasks were not included in the baseline schedule and for the high level of stochasticity sixteen tasks were not included in the schedule. In order to compute the optimal schedule utilizing the DH-procedure, for those tasks that were flagged as stochastically occurring, the RanGen input task duration values were manually reset to zero and the corresponding task resource utilization values were also reset to zero. The RanGen and DH raw data output values for the twenty low stochasticity level and twenty high stochasticity level networks solved optimally using the optimistic scheduling approach can be found in Appendix D.

Perfect Knowledge Schedules

Perfect knowledge schedules occur when all task occurrences and durations are known with certainty and are scheduled initially with complete knowledge. There are four types of perfect knowledge schedules that can exist under the conditions specified in this research.

1). Early-Low (EL) schedules occur when a low level of stochastic tasks (defined to be four of eight in this research) occur early in the schedule.

2). Late-Low (LL) schedules occur when a low level of stochastic tasks (four of eight tasks) occur late in the schedule.

3). Early-High (EH) schedules occur when a high level of stochastic tasks (defined to be eight of sixteen in this research) occur early in the schedule.

4).Late-High (LH) schedules occur when a high level of stochastic tasks (eight of sixteen) occur early in the schedule.

The perfect knowledge schedules were solved optimally using the DH-procedure. All tasks that did not occur were manually updated with a duration value of zero and zero resource usage. The raw data output values for the RanGen and DH perfect knowledge schedules can be found in Appendix D.

Step 2: Calculate Partial Buffer Sizes

The next step in the research process is to calculate the task duration values for the seven partial buffer approaches.

Fixed Percentage Buffers

One of the first contributions to the project scheduling literature utilizing the buffer concept is the CC/BM developed by Goldratt (1997). This method specifically addresses the variability associated with task duration estimates, the SRCP, but does not address the issue of STIs. As discussed in Chapter Three, the CC/BM approach espouses a 50% buffer sizing rule where 50% of the estimated task duration is scheduled as a part of the baseline schedule and half of the remaining 50% is scheduled at the end of the baseline schedule in the project buffer. Although not specifically defined as such, Selim (2002) addressed the SRCP with STI problem utilizing extreme buffer sizing methods. While the results of Selim (2002) indicated that the pessimistic approach resulted in better performance metrics, an acknowledgement was made that 100% buffering is simply not feasible in many project management environments. The first partial buffering approach sets the 50% buffer sizing rule defined by CC/BM as the upper limit and investigates two other intermediary sizes.

Three fixed buffer sizes were studied: 10%, 30%, and 50% respectively. Each of the buffer percentages was applied to the tasks that had been identified as stochastic tasks. For example, using a 50% buffer sizing rule, a stochastic task with a potential duration of eight was actually scheduled with a task duration of four. Because the DH-algorithm requires whole number inputs, any fractional results were rounded up to the next whole number.

JG-Generated Variable Partial Buffers

There are a total of four variable partial buffer sizing rules developed for investigation in this research. The first two are not dependent upon the optimal sequence of tasks as defined by the DH algorithm; they were based purely on the sequential task order as defined by the RanGen output task definition. The last two are based upon the optimal sequence of tasks, as defined by the DH algorithm. The four partial buffer size rules are defined as follows:

1. JG3 = (Duration of Current Stochastic Task)/(Sum of all potential stochastic task durations)
2. JG4 = (Task Stochastic Number) x(JG3)
3. JG5 = (Current Stochastic Task Duration) x (1 - % of Total Project Activity Time Remaining)
4. JG6 = (Current Stochastic Task Duration) x (1 - % of Total Potential Stochastic Task Activity Time Remaining)

Although not defined as a specific factor for investigation in this research, the distinction between the buffer size dependencies upon the location within the network optimal task sequence as opposed to the network sequential task sequence provides some insight into possible buffer location strategies. One of the key findings of Selim (2002) is that project schedulers need to pay close attention to stochastically occurring tasks in the later part of the schedule. To account for that recommendation, by definition, the JG5 and JG6 buffer sizes allocate a larger percentage of buffers to the stochastic tasks that occur later in the optimal sequence. The raw data files for the JG Partial Buffer Calculations can be found in Appendix E. An example of the low and high level of stochasticity JG partial buffer calculations for Network 1004 can be found in Figures 4 and 5, respectively.

							Low Level of Stochasticity			
Activity Number in Optimal Sequence	Activity Duration	% of Project Activity Time Remaining	JG 5 1-column C	% of Stochastic Project Activity Time Remaining	JG 6 1-column E	SN	JG3	JG4	JG5	JG6
1	0	1				0				
7	4	0.975				2				
3	6	0.9375	0.0625	0.911765	0.088235294	3.5	0.09	0.31	0.38	0.53
2	6	0.9				3				
9	9	0.84375	0.15625	0.779412	0.220588235	5.5	0.13	0.73	1.41	1.99
5	10	0.78125	0.21875	0.632353	0.367647059	6.5	0.15	0.96	2.19	3.68
8	1	0.775				1.25				
10	2	0.7625				1.75				
4	9	0.70625	0.29375	0.5	0.5	4.5	0.13	0.60	2.64	4.50
14	2	0.69375				1				
6	5	0.6625				2.5				
31	6	0.625				3				
12	3	0.60625				2.25				
20	4	0.58125				2.5				
11	4	0.55625				2				
22	4	0.53125				2				
13	7	0.4875	0.5125	0.397059	0.602941176	5	0.10	0.51	3.59	4.22
19	8	0.4375				4				
21	10	0.375	0.625	0.25	0.75	5.75	0.15	0.85	6.25	7.50
30	1	0.36875				0.5				
28	9	0.3125				4.75				
15	4	0.2875				2.75				
17	7	0.24375				3.5				
18	1	0.2375				1				
29	2	0.225				1.75				
25	1	0.21875				0.5				
16	8	0.16875	0.83125	0.132353	0.867647059	5	0.12	0.59	6.65	6.94
23	9	0.1125	0.8875	0	1	5.75	0.13	0.76	7.99	9.00
27	8	0.0625				5				
24	2	0.05				2				
26	8	0				4.5				
32	0	0				0				

160 Total Task Time
68 Total Stochastic Task Time -Low Level

Figure 4: Network 1004 low level of stochasticity JG5 and JG6 partial buffer calculations

							High Level of Stochasticity			
Activity Number in Optimal Sequence	Activity Duration	% of Project Activity Time Remaining	JG 5 1-column C	% of Stochastic Project Activity Time Remaining	JG 6 1-column E	SN	JG3	JG4	JG5	JG6
1	0	1				0				
7	4	0.975				2				
3	6	0.9375	0.0625	0.950819672	0.049180328	3.5	0.05	0.17	0.38	0.30
2	6	0.9	0.1	0.901639344	0.098360656	3	0.05	0.15	0.60	0.59
9	9	0.84375	0.15625	0.827868852	0.172131148	5.5	0.07	0.41	1.41	1.55
5	10	0.78125	0.21875	0.745901639	0.254098361	6.5	0.08	0.53	2.19	2.54
8	1	0.775				1.25				
10	2	0.7625				1.75				
4	9	0.70625	0.29375	0.672131148	0.327868852	4.5	0.07	0.33	2.64	2.95
14	2	0.69375				1				
6	5	0.6625	0.3375	0.631147541	0.368852459	2.5	0.04	0.10	1.69	1.84
31	6	0.625	0.375	0.581967213	0.418032787	3	0.05	0.15	2.25	2.51
12	3	0.60625				2.25				
20	4	0.58125	0.41875	0.549180328	0.450819672	2.5	0.03	0.08	1.68	1.80
11	4	0.55625				2				
22	4	0.53125				2				
13	7	0.4875	0.5125	0.491803279	0.508196721	5	0.06	0.29	3.59	3.56
19	8	0.4375	0.5625	0.426229508	0.573770492	4	0.07	0.26	4.50	4.59
21	10	0.375	0.625	0.344262295	0.655737705	5.75	0.08	0.47	6.25	6.56
30	1	0.36875				0.5				
28	9	0.3125	0.6875	0.270491803	0.729508197	4.75	0.07	0.35	6.19	6.57
15	4	0.2875				2.75				
17	7	0.24375				3.5				
18	1	0.2375				1				
29	2	0.225				1.75				
25	1	0.21875				0.5				
16	8	0.16875	0.83125	0.204918033	0.795081967	5	0.07	0.33	6.65	6.36
23	9	0.1125	0.8875	0.131147541	0.868852459	5.75	0.07	0.42	7.99	7.82
27	8	0.0625	0.9375	0.06557377	0.93442623	5	0.07	0.33	7.50	7.48
24	2	0.05				2				
26	8	0	1	0	1	4.5	0.07	0.30	8.00	8.00
32	0	0				0				

160 Total Task Time

122 Total Stochastic Task Time -High Level

Figure 5: Network 1004 high level of stochasticity JG5 and JG6 partial buffer calculations

Step 3: Solve Partial Buffer Networks Optimally with the DH Algorithm

All RanGen files were updated with the appropriate partial buffer task duration values and resolved using the DH Algorithm. The RanGen and DH-Algorithm raw data output files can be found in Appendix F. Summary Charts for the RanGen and DH output values can be found in Appendix G and Appendix H respectively. It should be noted that due to the limitations of the DH algorithm, all fractional calculated partial buffer sizes were rounded up to the next highest integer. The results of the DH-algorithm resulted in infeasible baseline schedules similar to the pessimistic and optimistic schedules generated in Selim (2002).

An example of the Appendix G and H Appendix data for Network 1004 is found Figure 6 and Figure 7, respectively.

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	0.60	0.59
3	3.5	6	0	0	6	6	0	0	0.6	1.8	3	0.09	0.31	0.38	0.53	0.6	1.8	3	0.05	0.17	0.38	0.30
4	4.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.60	2.64	4.50	0.9	2.7	4.5	0.07	0.33	2.64	2.95
5	6.5	10	0	0	10	10	0	0	1	3	5	0.15	0.96	2.19	3.68	1	3	5	0.08	0.53	2.19	2.54
6	2.5	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.10	1.69	1.84
7	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	5.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.73	1.41	1.99	0.9	2.7	4.5	0.07	0.41	1.41	1.55
10	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	5	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10	0.51	3.59	4.22	0.7	2.1	3.5	0.06	0.29	3.59	3.56
14	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
16	5	8	0	0	0	0	8	8	0.8	2.4	4	0.12	0.59	6.65	6.94	0.8	2.4	4	0.07	0.33	6.65	6.36
17	3.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	4	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	4.50	4.59
20	2.5	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.03	0.08	1.68	1.80
21	5.75	10	0	0	0	0	10	10	1	3	5	0.15	0.85	6.25	7.50	1	3	5	0.08	0.47	6.25	6.56
22	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
23	5.75	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	0.76	7.99	9.00	0.9	2.7	4.5	0.07	0.42	7.99	7.82
24	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
25	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	4.5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.30	8.00	8.00
27	5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.33	7.50	7.48
28	4.75	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.07	0.35	6.19	6.57
29	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	2.25	2.51
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 6: Network 1004 summary RanGen partial buffer input values

				DH-Alogirhm Output Files: Project Task Completion Times																			
				Perfect Knowledge Schedules						Buffered Schedules							Buffered Schedules						
				Low Level		High Level		Optimistic Schedules		Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	0	6	6	6	0	6	6	0	6	6	6	6	6	6	6	1	2	3	1	1	1	1
3	6	0	6	0	6	0	6	0	0	1	2	3	1	1	1	1	1	2	3	1	1	1	1
4	9	6	15	0	15	0	15	0	0	2	5	8	2	2	4	6	2	5	8	2	2	4	4
5	10	0	10	0	10	0	10	0	0	1	3	5	1	1	3	4	1	3	5	1	1	3	3
6	5	15	20	11	20	0	20	11	0	11	11	13	11	11	11	11	3	7	11	3	3	6	6
7	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	1	6	7	7	7	1	7	7	1	7	7	7	7	7	7	7	2	3	4	2	2	2	2
9	9	0	9	0	9	0	9	0	0	1	3	5	1	1	2	2	1	3	5	1	1	2	2
10	2	6	8	8	8	2	8	8	2	8	8	8	8	8	8	8	3	4	5	3	3	3	3
11	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	7	11	15	7	7	10	10
12	3	20	23	14	23	7	23	14	7	14	14	16	14	14	14	14	7	10	14	7	7	9	9
13	7	20	27	18	20	11	20	11	4	12	14	17	12	12	15	16	5	10	15	5	5	10	10
14	2	15	17	8	17	2	17	8	2	8	8	10	8	8	8	8	4	7	10	4	4	6	6
15	4	24	28	19	28	8	28	19	8	19	19	21	19	19	19	19	11	15	19	11	11	14	14
16	8	28	36	27	28	16	28	19	8	20	22	25	20	20	26	26	12	18	23	12	12	21	21
17	7	24	31	22	31	11	31	22	11	22	22	24	22	22	22	22	14	18	22	14	14	17	17
18	1	27	28	19	21	12	21	12	5	13	15	18	13	13	16	17	6	11	16	6	6	11	11
19	8	20	28	19	28	12	20	19	4	19	19	21	19	19	19	19	5	10	15	5	5	11	11
20	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	5	9	13	5	5	8	8
21	10	20	30	21	20	14	20	11	4	12	14	18	12	12	18	19	5	10	16	5	5	13	13
22	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	7	11	15	7	7	10	10
23	9	30	39	30	28	23	28	19	8	21	25	30	21	21	34	28	12	18	24	12	12	24	24
24	2	36	38	29	30	18	30	21	10	22	24	27	22	22	28	28	14	20	25	14	14	23	23
25	1	28	29	20	29	13	24	20	8	20	20	22	20	20	20	20	8	11	16	8	8	12	12
26	8	36	44	35	39	24	31	30	11	30	30	32	30	30	30	34	15	21	27	15	15	29	29
27	8	32	40	31	32	24	24	23	4	23	23	25	23	23	23	31	8	14	19	8	8	18	18
28	9	23	32	23	32	20	23	23	7	23	23	25	23	23	23	23	8	13	19	8	8	16	16
29	2	27	29	20	25	13	25	16	9	16	16	19	16	16	17	18	9	12	17	9	9	12	12
30	1	23	24	15	24	8	24	15	8	15	15	17	15	15	15	15	8	11	15	8	8	10	10
31	6	15	21	14	21	4	21	14	4	14	14	14	14	14	14	14	5	7	11	5	5	7	7
32	0	44	44	35	39	24	31	30	11	30	30	32	30	30	34	34	15	21	27	15	15	29	29

Figure 7: Network 1004 summary DH partial buffer output values

Step 4: Compute Performance Measures

One objective of this research is to determine if a partial buffering strategy would provide improvements in project duration and stability metric performance as compared to the extreme buffering measures of Selim (2002). The initial range of buffer sizes was used to provide a broad base of comparison with the objective of determining, in a quantifiable way, the partial buffering approaches that provide the most improvement in project metrics. The initial infeasible partially buffered baseline schedule results and the Selim (2002) extreme base schedule results were each compared with the perfect knowledge schedule results as an initial study to quantify the types of improvements that might be obtained form the partial buffering approach.

Project Duration Metric

The percentage change in project duration is calculated to quantify the project duration metric. It is calculated as the percentage change between the project makespan of the infeasible baseline schedule to project makespan of the perfect knowledge schedule and is comparable to the duration metric of Selim (2002). The average value for each of the five networks in the four network and resource factor combinations outlined in Table 1 (the 1000 networks, the 1100 networks, the 1200 networks and the 1300 networks) is calculated. Appendix I contains the duration metric calculations for all twenty networks.

Project Stability Metric

The stability measures developed in Selim (2002) were resequencing metrics used to provide 1) a count of changed task start times in the modified base schedule as compared to the perfect knowledge schedule, 2) a count of the number of tasks with changed preceding tasks in the modified base schedule as compared to the perfect knowledge schedule, 3) a count of the total number of tasks in the modified base schedule that had additional preceding tasks as compared to the perfect knowledge schedule, and 4) a measure to determine the total number of tasks for which at least one preceding task in the perfect knowledge schedule was no longer a preceding task in the modified base and the task had at least one new preceding task. as compared   This research presents a new metric to account for the changes in task start time. Task start time stability may be significant to project managers in order to coordinate with outside suppliers or to coordinate support from other high demand resources within the organization. Van de Vonder, Demeulemeest et al, (2004a and 2004b) have developed stability measures involving changes in the task start times based on the adapted float factor model of Tavares, Ferreira et al. (1998), but do not consider the SRCP with STI.

In this research, for each task in each network, the absolute difference of the task start times between the perfect knowledge schedule and the infeasible baseline schedules was calculated. The task start times for the tasks that ultimately did not occur in the perfect knowledge schedules were not included in the computations. The mean and standard deviation of the absolute values of the start time differences for the tasks in each network were computed. The average coefficient of variation of the five networks in each resource and network parameter combination noted in Table 1 was then computed and used as the stability metric.   Appendix J contains the stability metric calculations for the twenty networks.

Phase One Experiment Results

The initial investigation included a range of partial buffering strategies with the intent of determining if a partial buffering approach had an advantage over the extreme approaches of Selim (2002) and if so, which of the partial buffering approaches showed the most project metric performance improvements. Also, insight into whether or not there is a performance advantage of using a fixed buffer size as opposed to a variable partial buffering strategy that incorporates knowledge of the stochastic factors associated with the individual tasks was gained.

Figures 8 through 11 summarize the stability and duration metric data for all twenty of the networks, assuming a low level of stochasticity. The x axis in each graph designates each of the four types of network categories. Recall, from Table 1, the 1000 level networks correspond to a low level of network parameters and a low level of resource factor parameters. The 1100 networks have low network parameters and high resource factor parameters. The 1200 networks have high network parameters and low resource factor parameter and the 1300 networks have high network and resource parameters. The y axes correspond to the duration and stability metrics. For the duration metric, the y axis is the absolute percentage change in duration when adjusting from the base schedule to the perfect knowledge schedule. For the stability metric, the y axis is the defined as the coefficient of variation as described above.

Low Level of Stochasticity Performance Results

For the case where the stochastic tasks occur early in the schedule, the duration metric charts indicate that the 50% buffer sizing rule and the JG5 and JG6 buffer sizing rules outperform all of the other buffering techniques with the exception of one instance when the 30% buffering rule outperforms the JG5 and JG6 methods with the 1100 type networks. For the case where the stochastic tasks occur late in the schedule, the 50%, JG5 and JG6 methods outperform all of the other buffering techniques. The stability metric results are a little less conclusive. For the instance where the stochastic tasks occur early in the schedule, the various partial buffering techniques result in similar performance metrics with very little variation. The same conclusion can be made for the instance where the stochastic tasks occur late in the schedule, although the 50% buffer sizing rule does provide better performance results in all cases with the exception of the 1300 networks, when the JG5 and JG6 approaches perform slightly better.

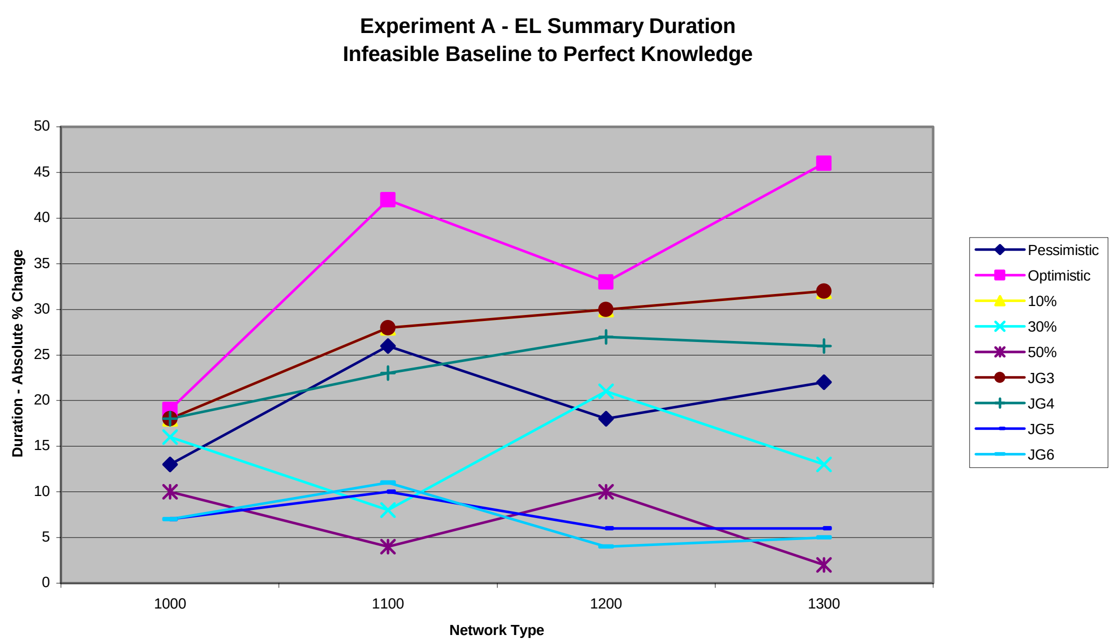

Figure 8: EL summary duration metric for infeasible to perfect knowledge

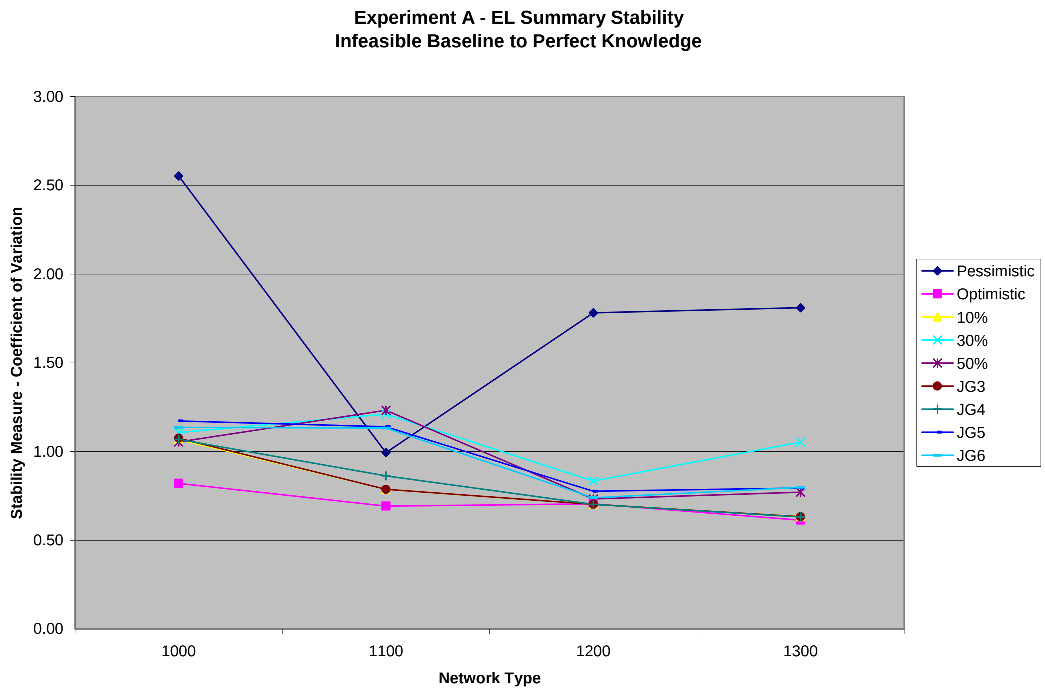

Figure 9: EL summary stability metric for infeasible to perfect knowledge

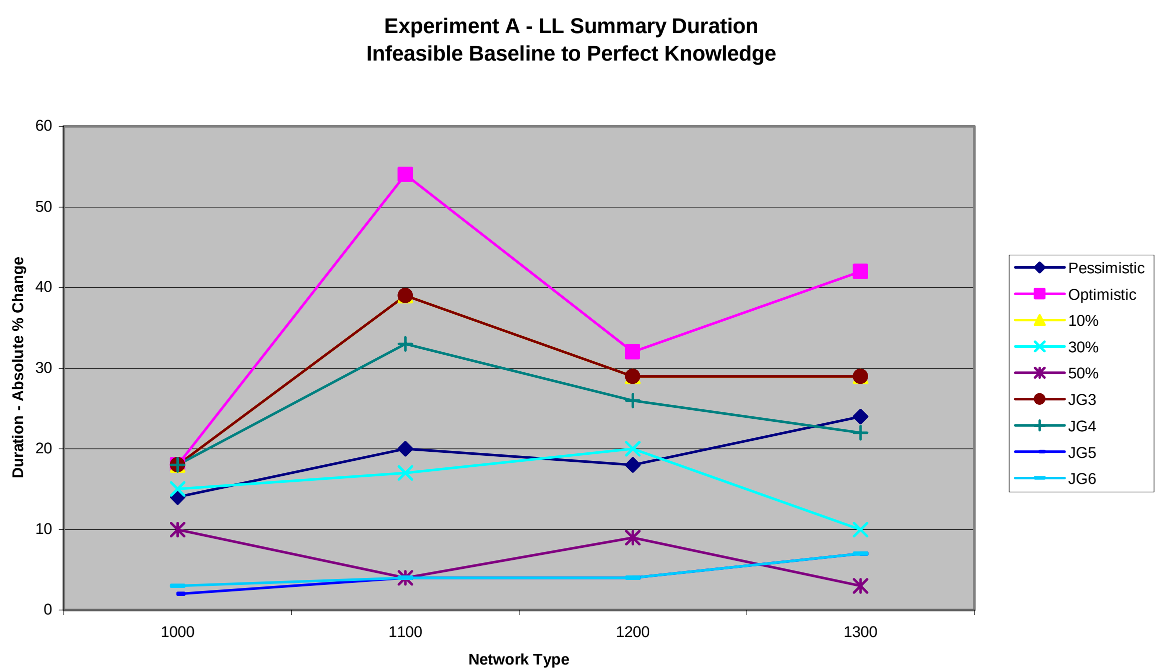

Figure 10: LL summary duration metric for infeasible to perfect knowledge

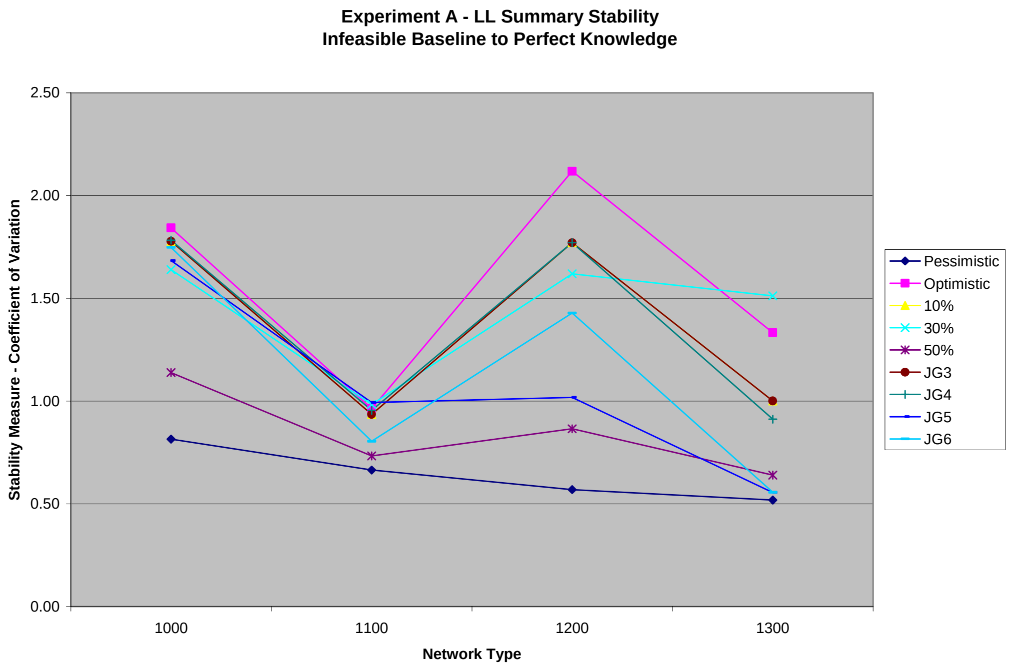

Figure 11: LL summary stability metric for infeasible to perfect knowledge

High Level of Stochasticity Performance Results

Figures 12 through 15 summarize the project duration and stability metric data for the twenty networks, assuming a high level of stochasticity. The duration metrics for both the early and late stochastic task occurrence instances indicate that the 50%, JG5 and JG6 buffer sizing methods result in the best performance. The stability metrics, however, are once again less conclusive. For the case where the stochastic tasks occur early in the schedule, all of the partial buffering techniques perform virtually identically. For the instances where the stochastic tasks occur late in the schedule, the 50%, JG5 and JG6 provide the most improvement with the exception of the 1000 networks where the 30% buffer sizing approach performs almost identically to JG6.

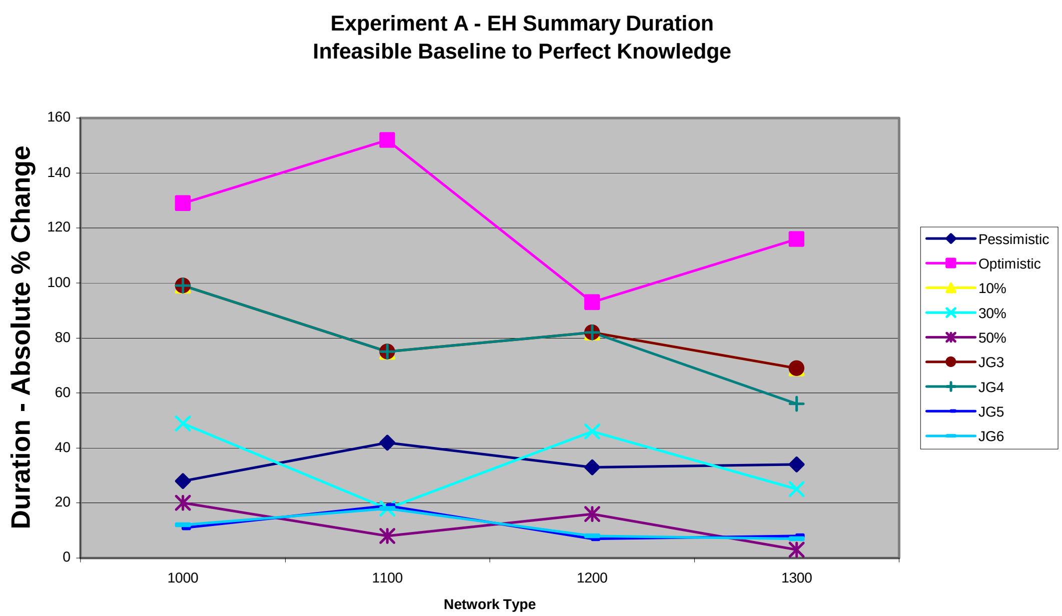

Figure 12: EH summary duration metric for infeasible to perfect knowledge

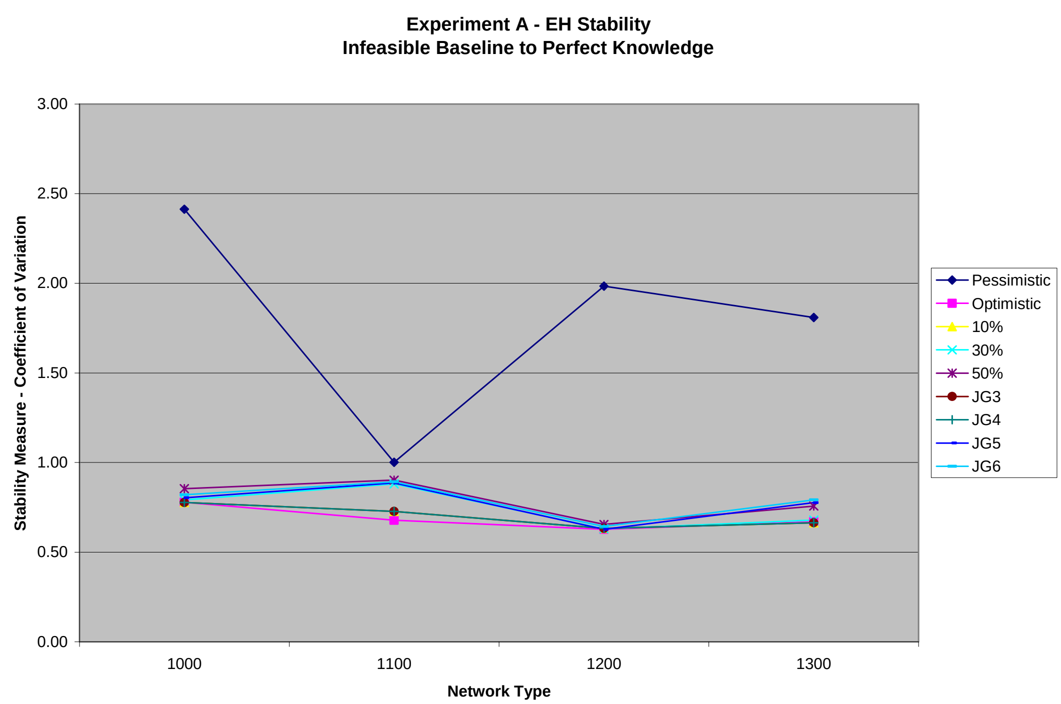

Figure 13: EH summary stability metric for infeasible to perfect knowledge

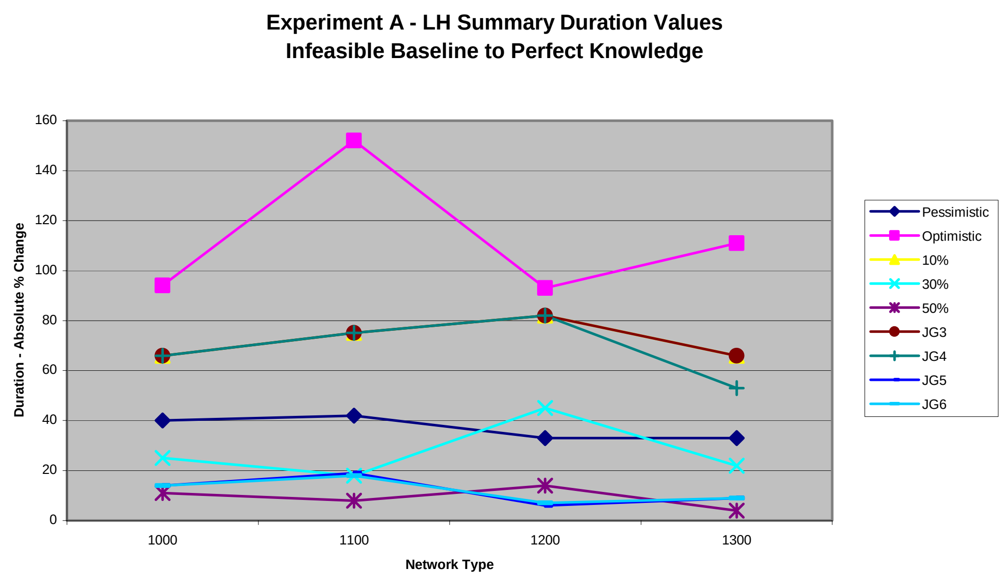

Figure 14: LH summary duration metric for infeasible to perfect knowledge

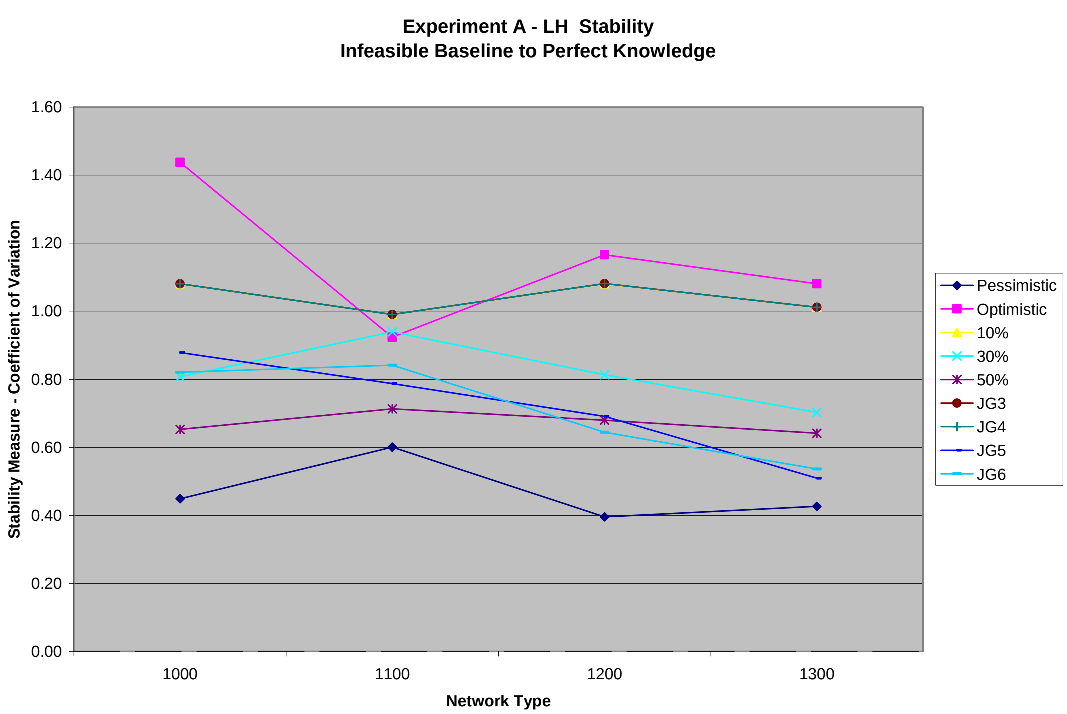

Figure 15: LH summary stability metric for infeasible to perfect knowledge

When compared to the extreme buffer sizing approaches of Selim (2002), in all cases the optimistic approach resulted in the worst duration metric performance. The optimistic approach also resulted in the worst stability performance with the exception of the cases where the stochastic tasks occurred early in the schedule. In those instances the optimistic results were either identical to the partial buffering techniques or very close. The pessimistic scheduling approach of Selim (2002) was outperformed by the 50%, JG5, and JG6 partial buffering approaches in all duration metric instances and for the stability instances where the stochastic tasks occur early in the schedule. For the stability metric instances in which the stochastic tasks occur late in the schedule, the pessimistic approach results in better performance, although by a limited margin.

Table 3 provides a summary of the phase one experiment results. Buffer sizing methods marked with an “x” are those that resulted in the best comparable project metric performance.

Table 3: Phase one experiment results summary

		EL-Duration	EL-Stability	LL-Duration	LL-Stability	EH-Duration	EH-Stability	LH-Duration	LH-Stability
Extreme Buffer Sizes	Pessimistic				X				X
	Optimistic		X				X		
Partial Buffer Sizes	10%		X				X		
	30%		X				X		
	50%	X	X	X	X	X	X	X	X
	JG3		X				X		
	JG4		X				X		
	JG5	X	X	X	X	X	X	X	X
	JG6	X	X	X	X	X	X	X	X

Based on these results, several preliminary observations and conclusions can be made. It is clear that improvements in project duration metrics can be made by utilizing a partial buffering approach. The optimistic approach seems to provide a very minimal advantage in stability metrics when the stochastic tasks occur early in the schedule and the pessimistic approach can provide some advantage in stability metrics when the stochastic tasks occur late in the schedule. The magnitude of project duration metric performance improvement utilizing a partial buffering approach is much greater than the stability metric performance improvements that result from utilizing a pessimistic or optimistic approach. Furthermore, where the project stability metrics are concerned, the optimistic and pessimistic approaches result in extreme differences in performance depending upon where the stochastic tasks actually occur in the schedule. While the pessimistic approach performs best when the stochastic tasks occur late in the schedule, the optimistic approach performs worst in this case. If the project manager chooses the wrong extreme approach, a significant reduction in stability metric performance will be sacrificed. The partial buffering approach results appear to minimize the stability metric performance margin.

Based on these results, the 50%, JG5 and JG6 partial buffering approaches were chosen for further analysis. The base Gantt Charts were generated for each of the schedules and a rescheduling policy was implemented to generate the modified base schedules. This process and the results and conclusions of phase two of the research are presented in Chapter Seven.

CHAPTER SEVEN: RESULTS AND CONCLUSION

Phase two of the research is to calculate the project metrics for the transition from the baseline schedule to the modified base line schedule.

Generate the Partial Buffer Infeasible Baseline Schedules

The first part of phase two of the research is to create the infeasible baseline schedule Gantt charts for the 50%, JG5 and JG6 partial buffering schemes. This resulted in twenty low level stochasticity Gantt charts and twenty high stochasticity level Gantt charts for each of the three partial buffering schemes. The raw data and resulting sixty infeasible baseline Gantt charts for the low level of stochasticity can be found in Appendix K. The raw data and resulting sixty infeasible baseline Gantt charts for the high level of stochasticity can be found in Appendix L. Examples of the 50% partial buffer low level and high level of stochasticity infeasible baseline Gantt charts found in Appendices K and L, respectively, for Network 1004 are illustrated in the following figures:

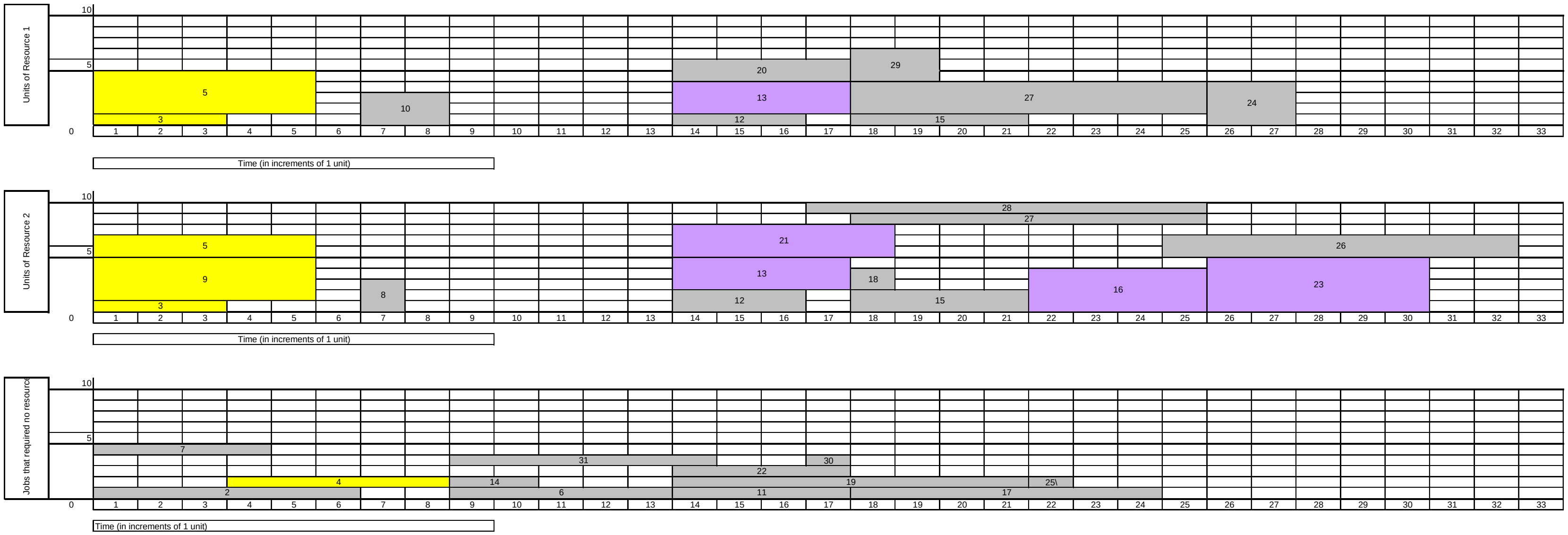

Figure 16: Network 1004 50% infeasible baseline Gantt chart – Low level of stochasticity

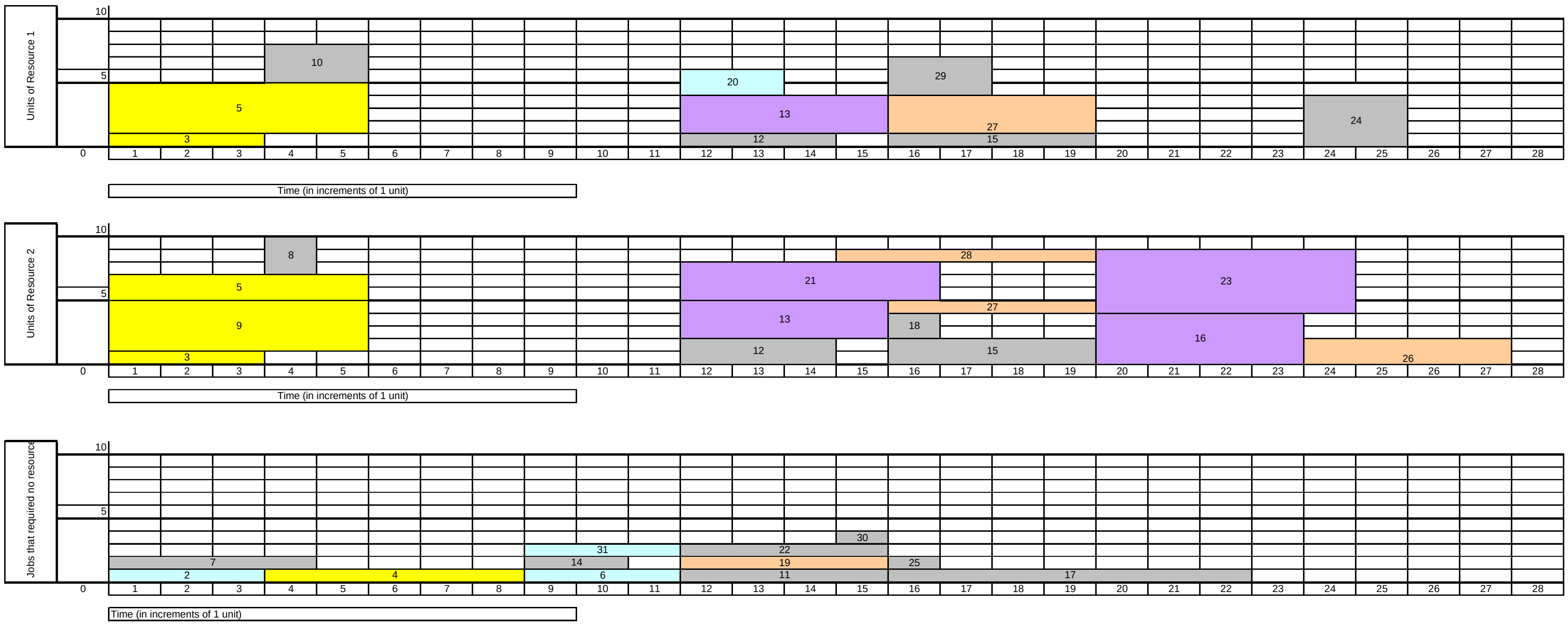

Figure 17: Network 1004 50% infeasible baseline Gantt chart – High level of stochasticity

Modify Baseline Gantt Charts

The Gantt charts were modified by utilizing the left shift or right shift rescheduling policy similar to the approach taken in Selim (2002). The resulting schedules are the modified baseline schedules corresponding to the EL, LL, EH and LH perfect knowledge schedules. Following the protocol of Selim (2002), the task sequence was unchanged assuming all resource utilization requirements were met. The low stochasticity modified Gantt charts can be found in Appendix K and the high stochasticity level modified Gantt charts can be found in Appendix L. The EL, LL, EH and LH modified Gantt Charts for the 50% partial buffer rule are found in the following figures:

Modified Base Schedule:
50% B modified to EL   Network 1004
Updated Durations:

Task	Scheduled Duration	Actual Duration
3	3	6
4	5	9
5	5	10
9	5	9
13	4	0
16	4	0
21	5	0
23	5	0

Figure 18: Network 1004 50% infeasible baseline modified to EL

Modified Base Schedule:
50% B modified to LL Network 1004
Updated Durations:

Task	Scheduled Duration	Actual Duration
3	3	0
4	5	0
5	5	0
9	5	0
13	4	7
16	4	8
21	5	10
23	5	9

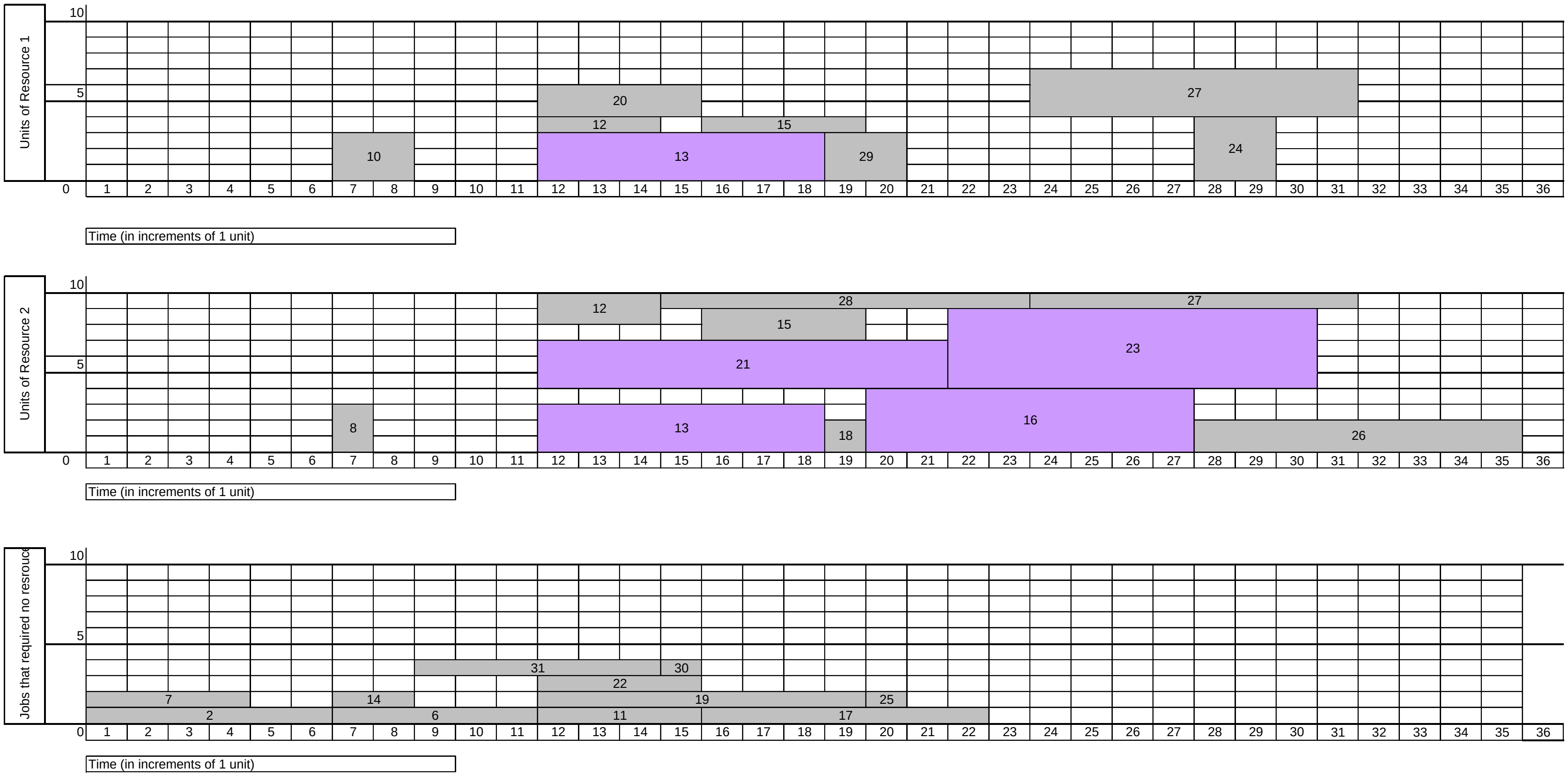

Figure 19: Network 1004 50% infeasible baseline modified to LL

Modified Base Schedule Network 1004 50% B to EH

Task Number	Scheduled Duration	Actual Duration
2	3	6
3	3	6
4	5	9
5	5	10
6	3	5
9	5	9
13	4	0
16	4	0
19	4	0
20	2	4
21	5	0
23	5	0
26	4	0
27	4	0
28	5	0
31	3	6

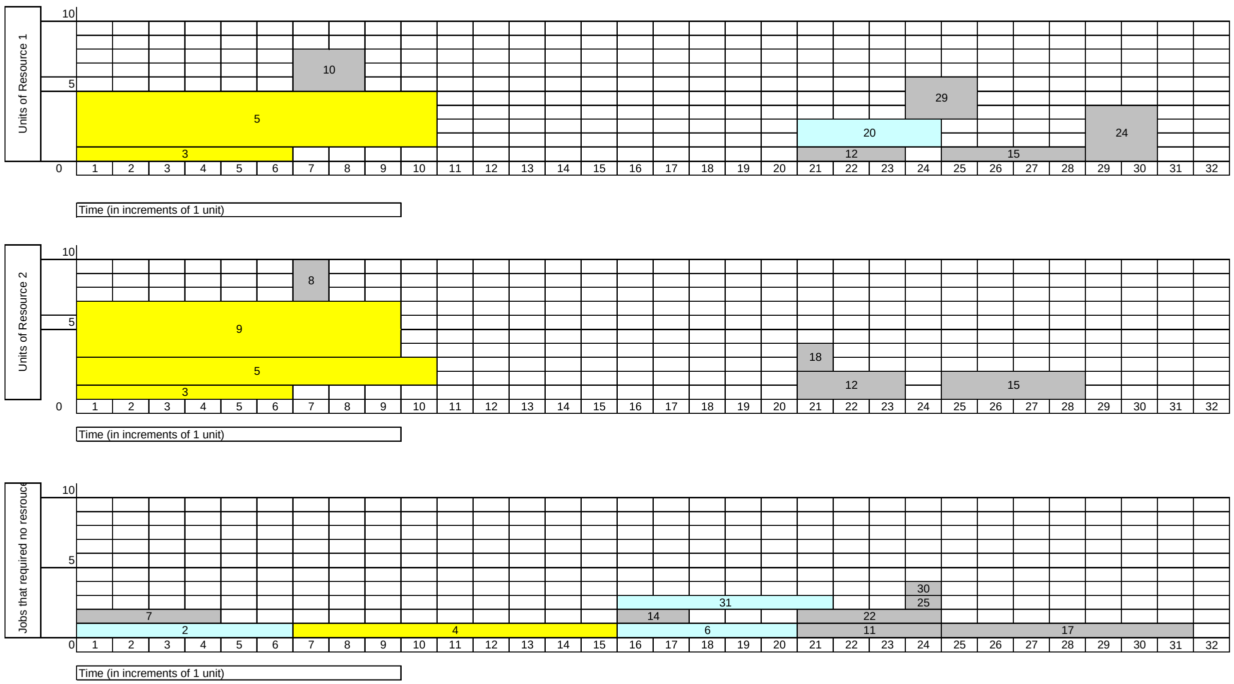

Figure 20: Network 1004 50% infeasible baseline modified to EH

Modified Base Schedule Network 1004 50% B to LH

Task Number	Scheduled Duration	Actual Duration
2	3	0
3	3	0
4	5	0
5	5	0
6	3	0
9	5	0
13	4	7
16	4	8
19	4	8
20	2	0
21	5	10
23	5	9
26	4	8
27	4	8
28	5	9
31	3	0

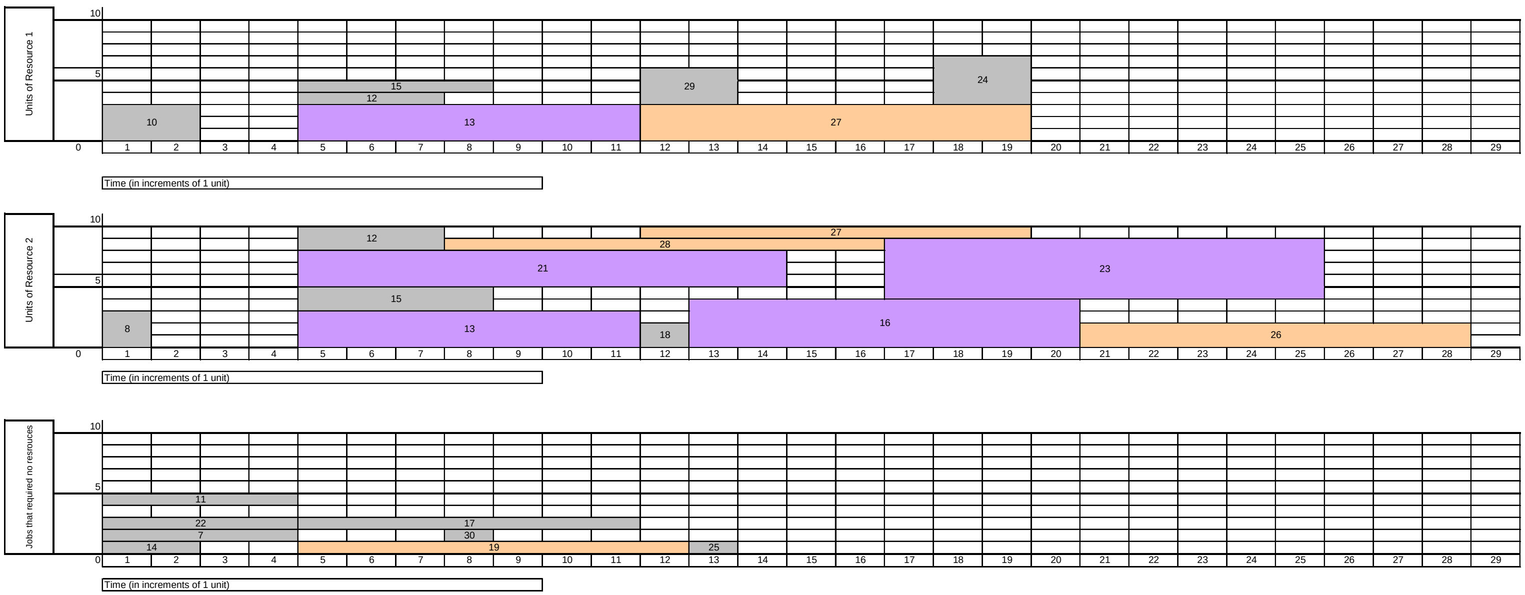

Figure 21: Network 1004 50% infeasible baseline modified to LH

The results and conclusions of the experiments are presented in this chapter. The initial comparison of the infeasible baseline schedule to perfect knowledge schedule metric performances resulted in a smaller, defined set of partial buffering schemes for further analysis. These three buffering schemes, 50%, JG5 and JG6 were modified into "as-run" schedules. The objective of this part of the research is to determine the scheduling approach that results in the least real-time manipulation of the schedule by the project manager. The project duration and project stability metrics defined in the previous chapter were calculated again, this time for the comparison of the infeasible baseline schedules to the modified baseline schedules. The data generated in Selim (2002) for the pessimistic and optimistic modified baseline schedules were used in this research for additional analysis between the partial buffering approaches to the extreme buffering approaches. Appendix M contains the raw data for the infeasible baseline to modified baseline duration metric calculations. Appendix N contains the raw data for the infeasible baseline to modified baseline stability metric calculations. The summary results of the low stochasticity and high stochasticity levels are presented in the figures below.

Figures 22 through 29 summarize the stability and duration metric data specific to the infeasible baseline schedule to modified baseline schedule for the pessimistic, optimistic, 50%, JG5 and JG6 buffer sizing schemes for all twenty of the networks, assuming a low level of stochasticity.

Low Level of Stochasticity Performance Results

For the instance in which the stochastic tasks occur early in the schedule (EL), (reference figure 22 and figure 23) the partial buffering approaches outperform the pessimistic approach for both the project duration and project stability metrics. The optimistic approach, however, is outperformed on the order of 30% when considering the duration metric as compared to the partial buffer performance metrics. The stability metric however shows the optimistic, 50%, JG5 and JG6 approaches all perform similarly.

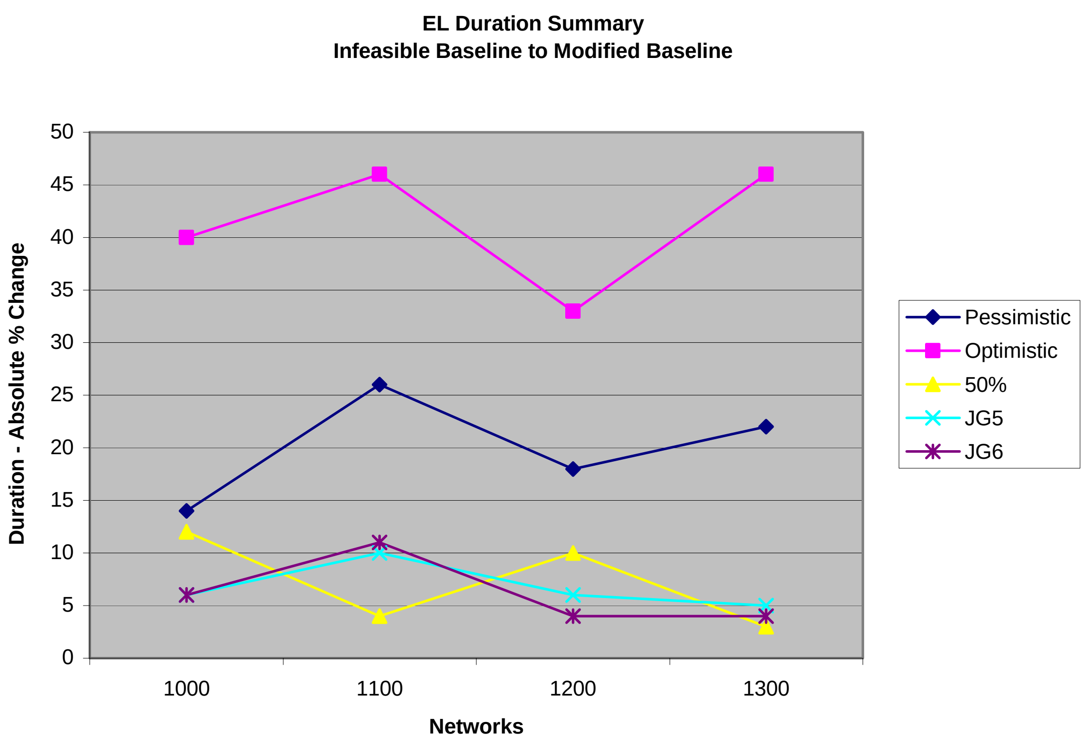

Figure 22: EL Summary duration metric for infeasible to modified

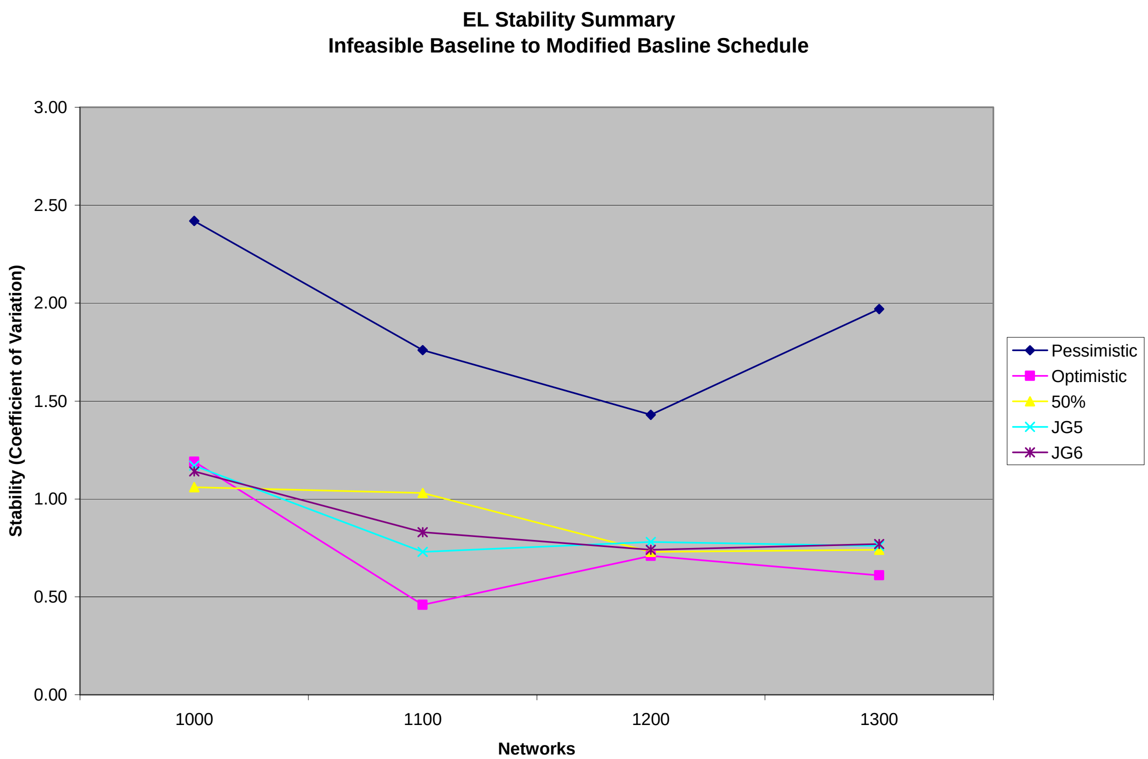

Figure 23: EL summary stability metric for infeasible to modified

For the case in which the stochastic tasks occur late in the schedule (LL), (reference figure 24 and figure 25) the duration metric results are similar to those found in the EL case. All of the partial buffering approaches outperform the pessimistic and optimistic approach. JG5 and JG6 perform virtually identically. The JG6 buffer provides a slight performance advantage in terms of the duration metric when the 1200 networks are considered and the 50% buffer provides a slight performance advantage when the 1300 networks are considered. The stability metric results indicate that the pessimistic approach provides the best performance results, however the 50% buffer is a close second.

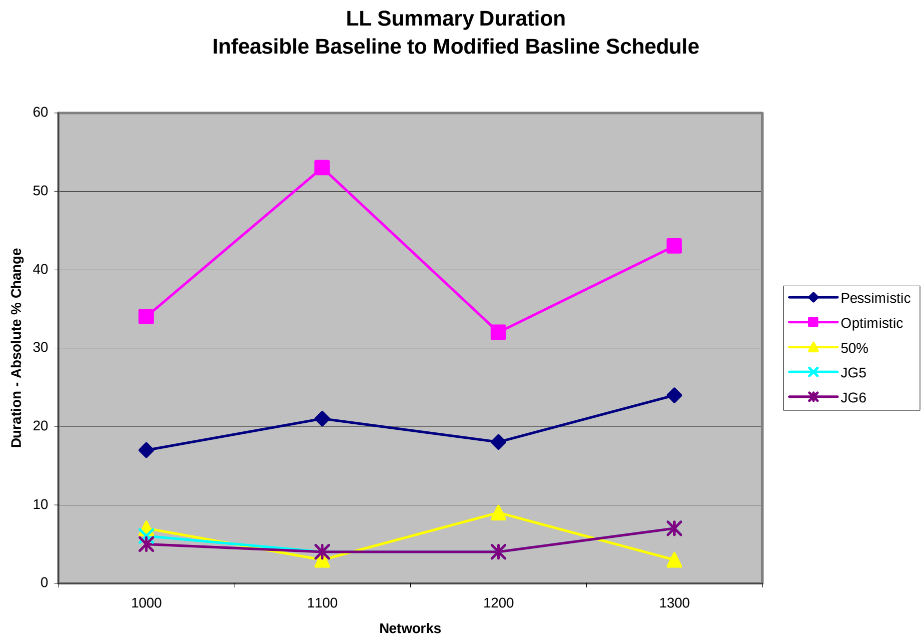

Figure 24: LL summary duration metric for infeasible to modified

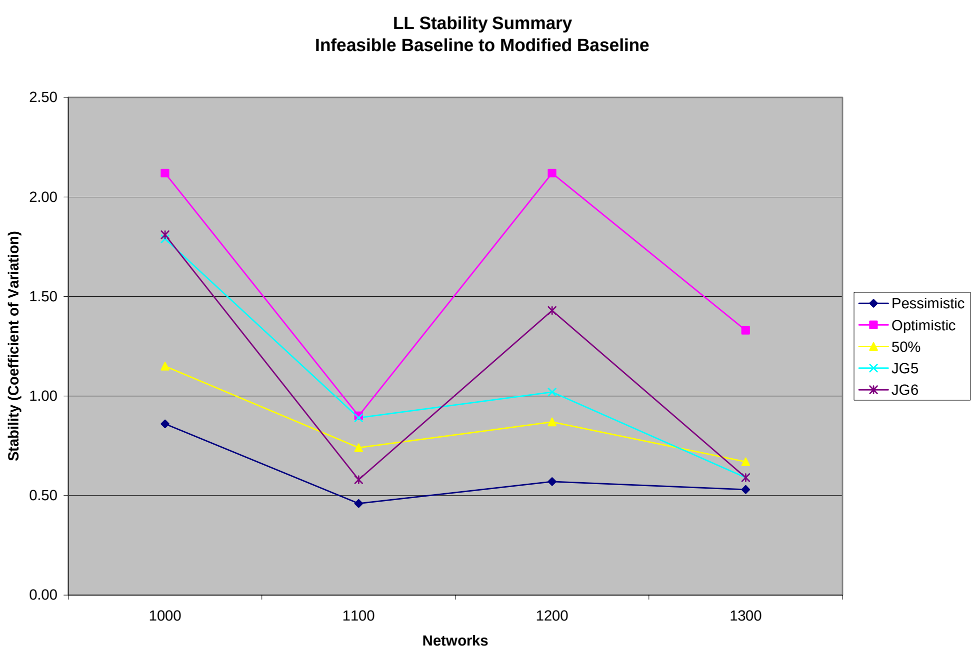

Figure 25: LL summary stability metric for infeasible to modified

Based on the results of the low level of stochasticity instances, we can conclude that the magnitude of performance improvement that can be made in the duration metric offsets the marginal advantage the extreme buffer sizing methods have in terms of the stability metric.

High Level of Stochasticity Performance Results

The results of the high level of stochasticity experiments are summarized in figure 26 and figure 27 below. The results are similar to those found in the low stochasticity analysis.

For the instance where the stochastic tasks occur early in the schedule (EH) (reference figures 28 and 29), the partial buffering approaches outperform both the pessimistic and optimistic approaches of Selim (2002). Buffer sizes JG5 and JG6 perform almost identically and tend to perform better than the 50% buffer for the 1000 and 1200 networks.

For the stability metric, the pessimistic approach results in the worst performance measure. The optimistic, 50%, JG5, and JG6 approaches all perform comparably.

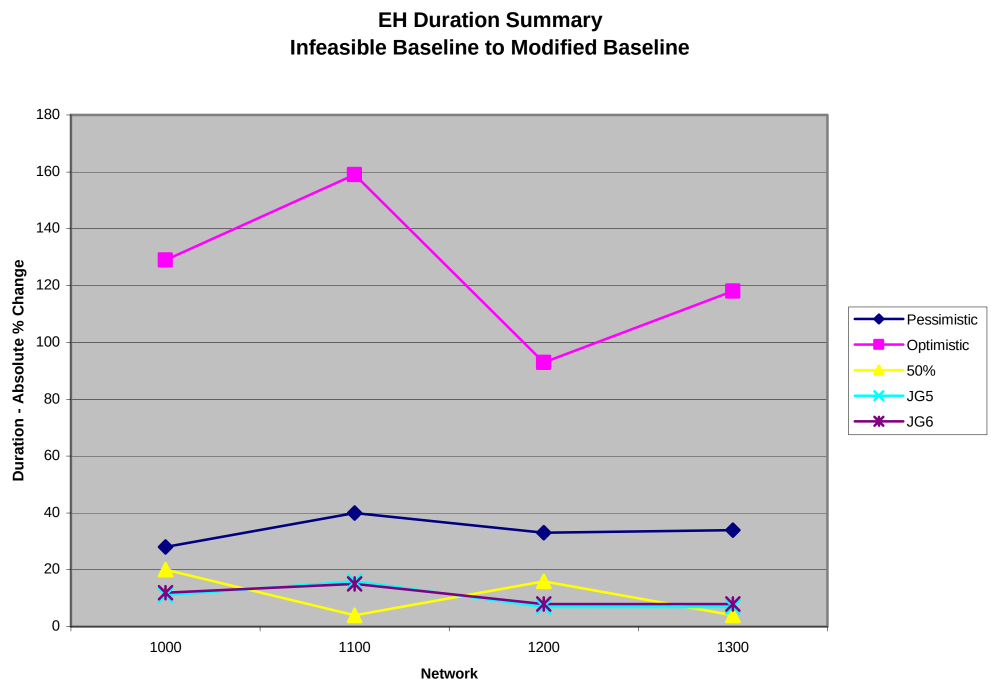

Figure 26: EH summary duration metric for infeasible to modified

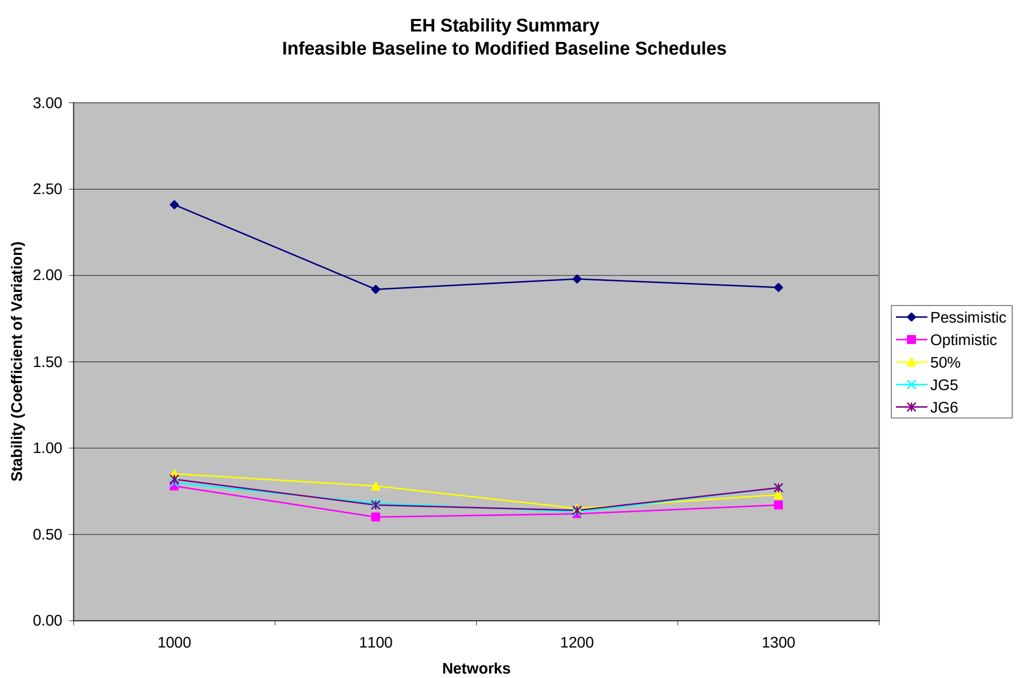

Figure 27: EH summary stability metric for infeasible to modified

For the instance in which the stochastic tasks occur late in the schedule, the duration metric results indicate that any of the partial buffering approaches would be preferable to the pessimistic or optimistic approaches. When the stability measure is considered, the optimistic approach would be least preferable; however, the results indicate the opposite extreme, the pessimistic approach, would in fact result in the best stability metric performance.

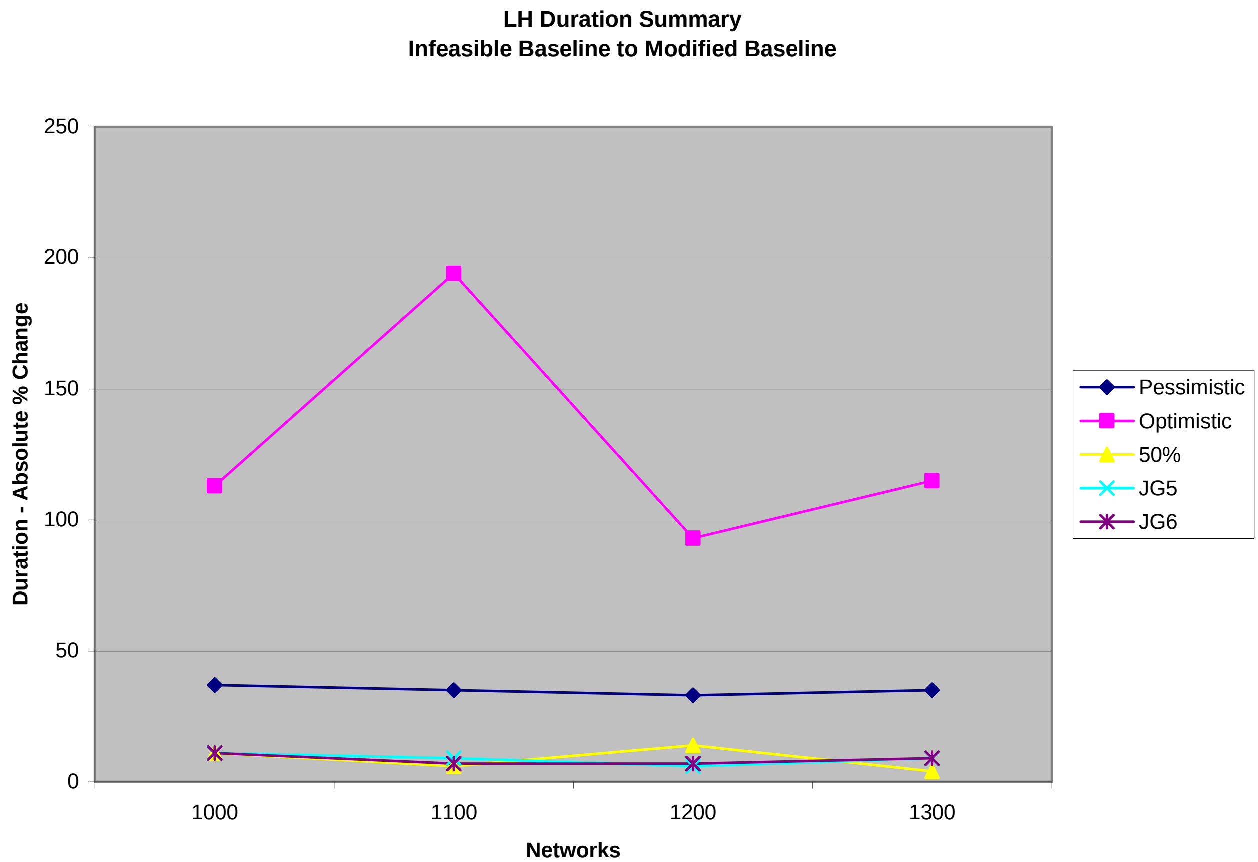

Figure 28: LH summary duration metric for infeasible to modified

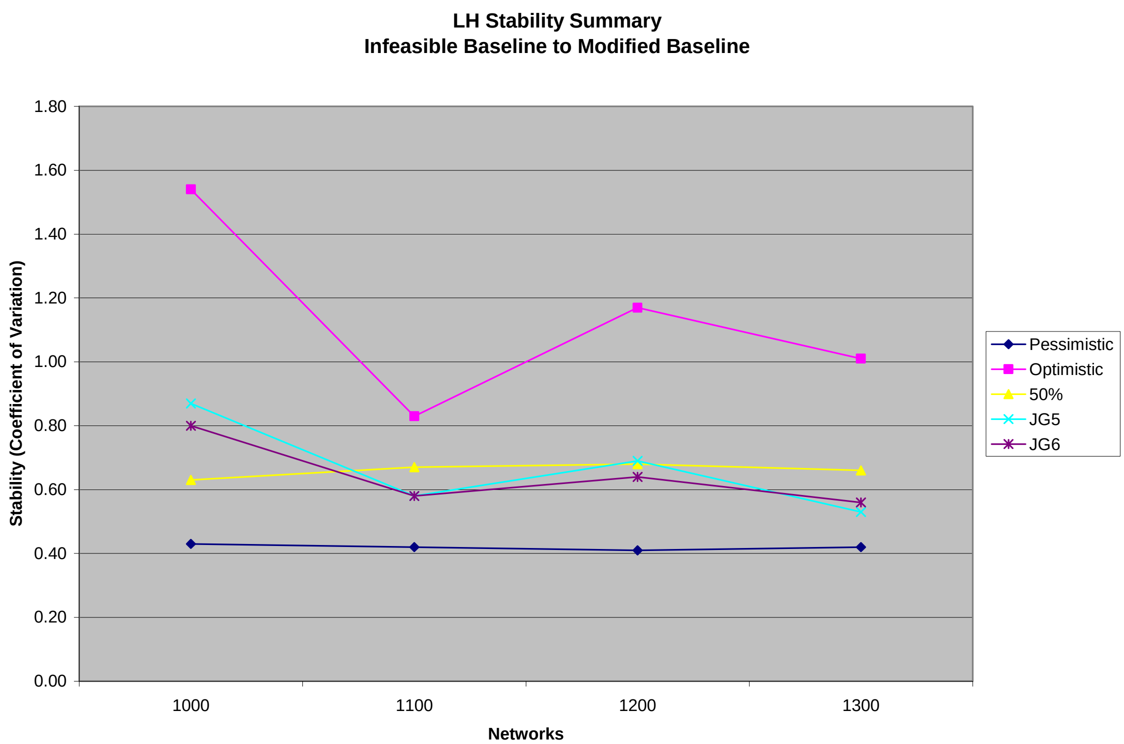

Figure 29: LH summary stability metric for infeasible to modified

In summary, for the duration metric, the partial buffering techniques outperform the extreme buffering techniques of Selim (2002) for all stochasticity level and stochasticity location combinations. For the stability metric, the data are less conclusive. The partial buffering methods perform similarly to the optimistic approach when the stochastic tasks occur early in the schedule. These methods clearly outperform the pessimistic method for the early location of the stochasticity. When the stochasticity occurs late in the schedule, the pessimistic scheduling method provides the best performance results, however the improvement is only marginal as compared to the partial buffering schedules. The important item to note is that the pessimistic and optimistic approaches result in extreme differences in stability performances depending upon where in the schedule the stochasticity actually occurs.

The following tables provide the summary data for the three partial buffering methods for the various network settings. The partial buffers all performed very similarly, however the charts indicate the buffer methods that produced even marginally improved performance. The buffer sizing schemes that performed identically were all noted in the table.

Table 4: 1000 network partial buffer performance

Low Network and Low Resource Paramaters				
	1000 Networks			
Duration	EL	LL	EH	LH
50%				X
JG5	X		X	X
JG6	X	X	X	X
Stability	EL	LL	EH	LH
50%	X	X	X	X
JG5			X	
JG6			X	

Table 5: 1100 network partial buffer performance

Low Network and High Resource				
	1100 Networks			
Duration	EL	LL	EH	LH
50%	X	X	X	X
JG5				X
JG6				X
Stability	EL	LL	EH	LH
50%				
JG5	X		X	X
JG6		X	X	X

Table 6: 1200 network partial buffer performance

High Network and Low Resource				
	1200 Networks			
Duration	EL	LL	EH	LH
50%				
JG5			X	X
JG6	X	X	X	X
Stability	EL	LL	EH	LH
50%	X	X	X	
JG5			X	
JG6	X		X	X

Table 7: 1300 network partial buffer performance

High Network and High Resoruce				
	1300 Networks			
Duration	EL	LL	EH	LH
50%	X	X	X	X
JG5				
JG6				
Stability	EL	LL	EH	LH
50%	X		X	
JG5	X	X		X
JG6	X	X		

Practical Implications

There are several practical project scheduling implications resulting from this research. The data supports the recommendation that project managers implement a partial buffering scheduling approach if the primary objective is to minimize the project duration. A partial buffering approach will lead to better project metric duration performance regardless of the settings of any of the research factors addressed.

When the stability metric is analyzed, the data indicates that the pessimistic approach produces minimal performance advantages as compared to the partial buffering approaches when the stochastic tasks occur late in the schedule. Similarly, when the stochastic tasks occur early in the schedule, the optimistic approach produces stability metric results that are minimally better than the partial buffering approaches. The issue is that for a minimal improvement in stability performance, the magnitude of project duration metric performance degradation is great. When comparing the various partial buffering technique performance metrics, the results are varied, so unfortunately there is no one “silver bullet” recommendation in terms of selecting which partial buffering approach is preferable. The 50%, JG5 and JG6 partial buffering approaches result in similar metric performance.

If the objective of the project manager is duration metric performance, for networks with low network and low resource parameters and for networks with high network and low resource parameters the JG6 buffering approach produces the best performance. For networks with low network and high resource parameters and for networks with high network and high resource parameters the 50% buffer sizing rule produces the best results for project duration metrics.

If the objective of the project manager is project stability metric performance, the recommendation becomes very subjective. For networks containing low network and low resource parameters, the 50% buffer appears to produce the best stability metric performance results regardless of the level and location of the stochasticity. For networks with low network and high resource parameters, the JG5 and JG6 buffers produce almost identical results, however there appears to be a slight advantage in using the JG5 approach for the low level of stochasticity when the tasks occur early in the schedule and using the JG6 buffer approach for the low level of stochasticity when the tasks occur late in the schedule. For networks with high network and low resource parameters, the choice between the 50% buffer and JG6 buffer result in similar project metric performance, In this case however, the 50% buffer approach has an advantage when the stochasticity level is low and the tasks occur late in the schedule and the JG6 approach has an advantage when the stochasticity level is high and the tasks occur late in the schedule. For the networks with high network parameters and high resource parameters, all of the buffer approaches perform equally well for the EL instance, the JG5 buffer approach tends to produce the best results for the LL and LH instances and the 50% buffer approach produces the best results for the EH instance.

CHAPTER EIGHT: CONTRIBUTIONS AND FUTURE RESEARCH

Chapter Eight provides a description of the contributions and practical implications of this research. Suggestions for future research are also presented.

Contributions

The primary contributions of the research are the introduction of the partial buffering concept to the SRCP with STI problem as a means to improve project duration and metric performance, the development of new partial buffering heuristics and the development of new project duration and stability metrics for the partial buffering approach. Seven partial buffering techniques were studied in this research; three were based on fixed buffer percentages and four were developed for this research and produced variable buffer levels based on knowledge of the stochastic nature of the tasks.

Four partial buffering heuristics, which incorporated knowledge of the stochasticity index of the tasks were developed as a part of this research. All four showed improvements to the extreme buffering approaches studied in Selim (2002). The two that incorporated knowledge of the optimal sequence of tasks (JG5 and JG6) produced better results than the two that were simply based on the sequential sequence list of tasks (JG3 and JG4). Three fixed-buffering approaches were also studied in the literature and one was proven to produce results similar to the JG5 and JG6 heuristics, the 50% buffer sizing rule.

The research conducted in Selim (2002) utilized extreme buffering approaches to address the SRCP with STI problem. The pessimistic approach provided better performance metrics than the optimistic approach; however, the practicality of using a pessimistic approach for large networks is questionable. Time and resource requirements are limited in a project environment and full buffering could lead to project duration and budget overruns. The partial buffering approach addresses this real-world concern and offers a quantifiable solution for improving duration and stability metrics.

The research conducted in Selim (2002) developed several stability metrics, however, none of the metrics accounted for the magnitude of change in task start times. The metric developed in this research provides a measure of tracking the absolute change in task start times when modifying the baseline schedule. Duration metrics were also developed in this research to measure partial-buffer schedule improvements when comparing the infeasible baseline schedule to the modified baseline schedule and the infeasible baseline schedule to the perfect knowledge schedule.

Future Research

There are many opportunities for future research in the area of SRCP with STI. This chapter will present specific areas of research utilizing the partial buffering approach.

Increase Project Size

One of the significant limitations to this research was the small project size (n=30). Real-world projects are much bigger in scope and the question becomes whether or not the partial buffer recommendations for small size projects would be the same, or better defined for larger projects. During the initial scoping of this research, the idea of applying the partial buffering approaches to larger size networks with similar parameters was considered. It is important for future researches to note that, after initial investigation into the constraints and limitations of both RanGen and the DH algorithm, it was determined that OS becomes a limiting factor when using the DH algorithm to optimize larger projects.

The initial project size definition indicated that projects of size n=60 could not be analyzed for OS values less than .85. It is noted in Selim (2002) that similar problems were encountered when setting the minimum and maximum parameters for OS in networks of size n=30. As stated in Selim (2002) "the initial low and high (OS) values that were used were 0.05 and .95. However, the networks generated using these values could not be solved using the DH procedure. After several adjustments and also after contacting Demeulemeester, the low value was increased and the high value was decreased slightly. Based on the findings of the preliminary investigation, the low value of OS was chosen to be .40 and the high value was chosen to be .85" (Selim, 2002 page 41). It is also noted in Brown (1995) that when attempting to demonstrate the use of the PRST algorithm on projects of large scale, the application of the DH procedure on networks of size n=100 was attempted "but the algorithm did not perform successfully for the problems. The possible reasons for the unsuccessful performance of the performance of the algorithm may be that it was not coded to accept up to six resource types or eight successors for an activity. Even if the algorithm performed successfully, the CPU time for the 100-activity problems could be prohibitive considering a maximum time of 19676 CPU seconds for a 32-activity network" (page 75, Brown 1995). Brown (1995) also notes that an attempt was made to solve the Large Multiple Project Networks that he developed with the DH-procedure, but the algorithm did not perform successfully for those problem instances either (page 78, Brown 1995). It is also noted that in recent research conducted utilizing the buffer approach and DH procedure for various applications as addressed in Chapter Three, that the network sizes were limited to 30 (Van de Vonder, Demeulemeester et al. 2004b) and 50 (Herroelen and Leus 2001a) respectively.

New Partial Buffering Scheduling Heuristics and Metrics

It was determined in this research that the 50% partial buffering approach produced results comparable to those of the JG5 and JG6 buffering approaches. The primary distinction between these methods is that the 50% approach is a fixed buffer size regardless of where the stochastic tasks occur in the network and the JG5/JG6 approaches are based on knowledge of the stochasticity factor. By definition, the JG5 and JG6 approaches allocate a higher buffer percentage to those tasks that occur later in the schedule. The rationale for the increased buffer size for tasks scheduled later in the schedule was based on the recommendations of Selim (2002). Additional partial buffer heuristics could be developed that incorporate knowledge of resource requirements and corresponding metrics related to the resource allocation and usage could be developed.

Incorporate CC/BM Techniques into the Partial Buffering Strategy

The methodology of the CC/BM proposed by Goldratt (1997) offers several areas of potential research that could be incorporated into the partial buffering approach. Specifically, the notion of a project buffer in which a portion of the task buffer is aggregated to a larger buffer at the end of the schedule could be explored. The resource and feeding buffers as defined by Goldratt (1997) could also be applied. This concept would require a new buffer management policy other than the left shift and right shift control policies. The idea of rescheduling during project execution would need to be incorporated.

Rescheduling Procedures

This research utilized the left shift and right shift rescheduling policies whenever a task disruption occurred. Another option would be to evaluate the improvements that could be made when implementing an optimal rescheduling policy each time an interruption occurred. Preliminary research conducted by Herroelen and Leus (2004b, page 1605) indicates that updating the schedule using an optimal rescheduling mechanism, such as the DH-branch and bound algorithm, at intermediary points in the schedule can have a beneficial effect on project makespan performance, however the impact on stability was not considered. Additional research to determine the effects on stability metrics and the potential tradeoff between project makespan and stability metrics when an optimal rescheduling policy is applied to the SRCP with STI problem can be conducted.

APPENDIX A
RANGEN INPUT REQUIREMENTS

The steps of generating networks using RanGen:

1. Number of activities:
2. Maximum number of generations (=0) or timelimit (=1):
3. Starting number of the network files:
4. Single (=0) or multi mode (=1) problems:
5. Without (=0) or with resources (=1):
6. Number of resource types:
7. Data for the resource demand matrix:
    a. resource factor RF (=0) or resource use RU (=1):
    b. number of instances for RF (max. 4):
        i. instance 1:

8. Date for the resource demand and resource availability:
    a. resource strength RS (=0) or RC (=1):
    b. number of instances:
        i. instance 1:

9. Do you want to change the following instances? (1=yes/0=no)
    a. seed value = 10
    b. number of instances per instance = 10
    c. maximal activity duration = 10

10. CI values with corresponding number of networks

10: XX

9: XX

8: XX

7: XX

6: XX

5: XX

4: XX

3: XX

2: XX

Total number of generated networks: XXXX

11. Number of instances for complexity index CI (max. 10)

    (0 if random selection is sufficient):

    value of CI for instance 1:

    Are you sure? (1=Y / 0=N)

APPENDIX B
DH ALGORITHM INPUT REQUIREMENTS

The format for the input file to the DH algorithm is as follows:

1 record

# of activities # of resources

2 record

blank

3 record

# of resource type 1 # of resource type 2 etc.

4 record

blank

5 record

1 column – task duration

2 ==> (1+k) column (where k is the # of resource types) **-** # of resources of each type used by the task

k+2 column **-** # of successor tasks

(k+2) + 1 ==>a + (k+3) columns (where a is the # of successors) – successor tasks

APPENDIX C
NETWORK SUMMARY CHARTS

Network 1004
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	5	2	3	5	7	9						
2	6	0	6	0	0	2	3	4	14	10	8	6						5	6.5
3	6	0	6	1	1	3	3.5	2	10	4								9	5.5
4	9	6	15	0	0	4	4.5	3	31	14	6							4	4.5
5	10	0	10	4	2	5	6.5	1	6									3	3.5
6	5	15	20	0	0	6	2.5	7	22	21	20	19	13	12	11			2	3
7	4	0	4	0	0	7	2	8	31	21	20	19	17	16	13	12		31	3
8	1	6	7	0	3	8	1.25	6	20	19	17	16	13	12				6	2.5
9	9	0	9	0	4	9	5.5	7	30	29	28	25	21	18	11			20	2.5
10	2	6	8	3	0	10	1.75	6	31	30	27	25	23	17				12	2.25
11	4	20	24	0	0	11	2	3	27	17	15							7	2
12	3	20	23	1	2	12	2.25	6	30	29	28	26	25	23				11	2
13	7	20	27	3	3	13	5	4	29	27	24	18						22	2
14	2	15	17	0	0	14	1	3	28	19	16							10	1.75
15	4	24	28	1	2	15	2.75	2	23	16								8	1.25
16	8	28	36	0	4	16	5	1	24									14	1
17	7	24	31	0	0	17	3.5	1	26									21	5.75
18	1	27	28	0	2	18	1	1	23									23	5.75
19	8	20	28	0	0	19	4	1	25									13	5
20	4	20	24	2	0	20	2.5	1	23									16	5
21	10	20	30	0	3	21	5.75	1	23									27	5
22	4	20	24	0	0	22	2	1	24									28	4.75
23	9	30	39	0	5	23	5.75	1	32									26	4.5
24	2	36	38	4	0	24	2	1	32									19	4
25	1	28	29	0	0	25	0.5	1	32									17	3.5
26	8	36	44	0	2	26	4.5	1	32									15	2.75
27	8	32	40	3	1	27	5	1	32									24	2
28	9	23	32	0	1	28	4.75	1	32									29	1.75
29	2	27	29	3	0	29	1.75	1	32									18	1
30	1	23	24	0	0	30	0.5	1	32									30	0.5
31	6	15	21	0	0	31	3	1	32									25	0.5
32	0	44	44	0	0	32	0	0											

Network 1010	Early Schedule Low Level (yellow)
N = 30	Early Schedule High Level (light blue)
Resource Types = 2	Late Schedule Low Level (purple)
Max Units of Available of Each Resource Type = 10	Late Schedule High Level (orange)
Low Network Parameters	
Low Resource Paramters	
DH Solution Summaries	

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	8	2	4	5	7	8	9	13	19			
2	8	0	8	0	0	2	4	1	3									7	6
3	7	8	15	0	0	3	3.5	3	18	15	6							15	5.5
4	1	0	1	0	1	4	0.75	3	18	15	6							11	5
5	8	0	8	1	0	5	4.25	3	18	15	6							5	4.25
6	3	15	18	2	0	6	2	5	31	30	14	12	11					2	4
7	10	0	10	4	0	7	6	5	17	15	14	12	10					12	4
8	6	0	6	0	0	8	3	7	31	30	27	21	17	16	14			14	3.75
9	2	0	2	0	3	9	1.75	6	29	27	18	17	16	15				3	3.5
10	1	10	11	3	0	10	1.25	6	27	25	23	21	18	16				8	3
11	8	18	26	4	0	11	5	5	27	23	21	17	16					19	2.75
12	8	18	26	0	0	12	4	6	29	27	26	25	23	20				6	2
13	1	0	1	0	1	13	0.75	6	28	26	24	23	21	17				9	1.75
14	6	18	24	2	1	14	3.75	5	28	26	25	23	22					10	1.25
15	8	15	23	4	2	15	5.5	3	24	23	21							4	0.75
16	2	26	28	0	0	16	1	3	26	24	22							13	0.75
17	2	26	28	2	5	17	2.75	2	25	22								30	6.75
18	7	24	31	1	2	18	4.25	2	24	22								31	5
19	5	0	5	1	0	19	2.75	2	27	22								29	5
20	6	26	32	1	0	20	3.25	1	21									25	4.5
21	8	32	40	0	0	21	4	1	22									18	4.25
22	1	40	41	0	3	22	1.25	1	32									21	4
23	1	26	27	0	0	23	0.5	1	32									20	3.25
24	1	32	33	2	4	24	2	1	32									17	2.75
25	7	33	40	4	0	25	4.5	1	32									26	2
26	4	28	32	0	0	26	2	1	32									24	2
27	1	26	27	0	0	27	0.5	1	32									22	1.25
28	1	26	27	2	0	28	1	1	32									28	1
29	8	28	36	4	0	29	5	1	32									16	1
30	10	23	33	4	3	30	6.75	1	32									23	0.5
31	10	18	28	0	0	31	5	1	32									27	0.5
32	0	41	41	0	0	32	0	0											

Network 1015

N = 30

Resource Types = 2

Max Units of Available of Each Resource Type = 10

Low Network Parameters

Low Resource Paramters

DH Solution Summaries

Legend
Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	8	2	3	4	5	6	7	8	9			
2	7	0	7	0	1	2	3.75	7	31	30	29	20	16	14	13			12	5
3	9	0	9	0	0	3	4.5	4	30	29	14	11						17	5
4	4	0	4	1	0	4	2.25	6	31	30	27	17	16	13				7	4.5
5	3	0	3	3	0	5	2.25	4	30	21	20	12						3	4.5
6	5	0	5	2	0	6	3	3	31	30	10							2	3.75
7	8	0	8	1	1	7	4.5	3	31	30	10							30	3.5
8	2	0	2	0	2	8	1.5	7	31	30	29	27	24	21	15			6	3
9	3	0	3	2	1	9	2.25	5	29	28	20	16	14					13	3
10	2	8	10	0	2	10	1.5	3	29	20	13							11	2.5
11	5	9	14	0	0	11	2.5	8	28	26	25	21	20	19	18	16		5	2.25
12	9	3	12	2	0	12	5	3	31	27	13							9	2.25
13	6	12	18	0	0	13	3	3	28	24	15							4	2.25
14	1	9	10	0	5	14	1.75	3	28	24	15							14	1.75
15	4	18	22	0	0	15	2	5	26	25	23	19	18					8	1.5
16	7	14	21	4	4	16	5.5	3	24	23	22							10	1.5
17	10	4	14	0	0	17	5	3	29	23	22							22	6
18	7	22	29	2	3	18	4.75	1	22									16	5.5
19	9	22	31	0	1	19	4.75	1	22									18	4.75
20	8	14	22	0	2	20	4.5	1	27									19	4.75
21	8	14	22	2	0	21	4.5	1	23									20	4.5
22	8	31	39	4	4	22	6	1	32									21	4.5
23	6	22	28	3	0	23	3.75	1	32									28	4.5
24	6	21	27	0	0	24	3	1	32									25	4
25	8	22	30	0	0	25	4	1	32									31	3.75
26	3	22	25	5	0	26	2.75	1	32									23	3.75
27	5	22	27	0	0	27	2.5	1	32									29	3.75
28	7	18	25	0	4	28	4.5	1	32									24	3
29	6	25	31	0	3	29	3.75	1	32									26	2.75
30	6	9	15	0	2	30	3.5	1	32									27	2.5
31	7	12	19	1	0	31	3.75	1	32									15	2
32	0	39	39	0	0	32	0	0											

Network 1020
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level (yellow)
Early Schedule High Level (light blue)
Late Schedule Low Level (purple)
Late Schedule High Level (orange)

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	1	2	4	5	6	7						
2	7	0	7	0	0	2	3.5	5	19	12	10	3						19	5
3	2	7	9	0	0	3	1	6	30	17	16	15	9	8				5	4.75
4	2	0	2	1	1	4	1.5	6	31	30	19	17	15	14	9			8	4.75
5	8	0	8	3	0	5	4.75	6	31	30	21	17	16	15	14	13	11	10	4.25
6	5	0	5	0	0	6	2.5	4	30	29	16	15	13	8				16	4
7	5	0	5	3	0	7	3.25	4	31	21	16	15	13	10				2	3.5
8	8	9	17	3	0	8	4.75	1	31	28	24	23	18	14				11	3.5
9	1	9	10	4	0	9	1.5	7	29	28	24	23	22	13				7	3.25
10	7	7	14	3	0	10	4.25	5	30	29	28	23	22	20				6	2.5
11	7	8	15	0	0	11	3.5	6	29	28	23	22	20					17	2.5
12	2	7	9	0	2	12	1.5	1	23	21	14	13						4	1.5
13	1	10	11	0	0	13	0.5	9	20									12	1.5
14	4	17	21	1	2	14	2.75	6	20									9	1.5
15	10	9	19	0	0	15	5	3	20									3	1
16	7	9	16	0	2	16	4	1	20									13	0.5
17	4	10	14	2	0	17	2.5	6	20									31	7.25
18	6	17	23	2	5	18	4.75	2	21									21	5.5
19	9	7	16	0	2	19	5	1	21									29	5.5
20	6	27	33	3	0	20	3.75	3	27	26	25							15	5
21	10	23	33	2	0	21	5.5	1	27	26	25							18	4.75
22	7	23	30	1	3	22	4.5	1	27	25								30	4.75
23	4	24	28	0	3	23	2.75	1	25									22	4.5
24	6	21	27	1	0	24	3.25	1	26									27	4
25	6	33	39	3	0	25	3.75	1	32									20	3.75
26	4	33	37	4	0	26	3	1	32									25	3.75
27	7	33	40	0	2	27	4	1	32									24	3.25
28	1	23	24	0	3	28	1.25	1	32									26	3
29	9	27	36	2	2	29	5.5	1	32									14	2.75
30	9	14	23	1	0	30	4.75	1	32									23	2.75
31	10	17	27	6	3	31	7.25	1	32									28	1.25
32	0	40	40	0	0	32	0	0											

Network 1028
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	6	2	4	6	7	9	10					
2	8	0	8	1	0	4	4.25	3	14	12	3							11	5.25
3	2	8	10	4	2	7	2.5	1	5									12	5
4	3	0	3	1	4	10	2.75	8	31	24	23	20	18	15	13	11		6	4.5
5	6	10	16	0	1	2	3.25	4	31	30	24	8						2	4.25
6	8	0	8	2	0	6	4.5	3	30	24	8							9	4
7	3	0	3	0	0	9	1.5	3	30	24	8							10	3.25
8	1	16	17	3	0	11	1.25	8	29	23	20	19	18	17	15	13		7	3
9	8	0	8	2	0	14	4.5	9	30	29	28	23	22	21	20	19	18	5	3
10	4	0	4	0	3	3	2.75	8	30	27	22	21	20	19	17	16		4	1.75
11	9	3	12	0	0	12	4.5	5	30	29	19	17	16					3	1.75
12	10	8	18	0	0	5	5	5	30	29	27	23	20					15	1.5
13	3	17	20	2	0	8	2	4	28	26	22	21						13	1.5
14	1	8	9	2	1	24	1.25	4	29	27	26	19						14	1
15	2	17	19	0	2	15	1.5	1	16									8	1
16	7	19	26	0	0	13	3.5	2	26	25								29	0.5
17	3	21	24	4	1	19	2.75	2	28	26								20	6.5
18	3	21	24	0	0	29	1.5	2	27	25								23	5.75
19	4	17	21	3	3	20	3.5	1	25									30	5.25
20	10	18	28	0	5	16	6.25	1	25									22	5.25
21	4	20	24	0	0	21	2	1	25									16	4.75
22	7	26	33	2	0	17	4	1	25									28	4.5
23	10	24	34	3	0	18	5.75	1	26									25	4.5
24	6	16	22	0	1	30	3.25	1	25									24	3.75
25	9	33	42	1	0	27	4.75	1	32									19	3.25
26	2	34	36	3	0	23	1.75	1	32									31	3.25
27	4	24	28	3	4	22	3.75	1	32									18	2.25
28	5	33	38	1	2	31	3.25	1	32									27	2.25
29	1	18	19	5	3	28	2.5	1	32									17	2
30	10	21	31	0	0	25	5	1	32									21	2
31	5	28	33	0	0	26	2.5	1	32									26	1
32	0	42	42	0	0	32	0	0											

Network 1102
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	6	2	3	4	6	7	9					
2	10	11	21	0	9	2	7.25	2	21	5								5	8
3	2	0	2	2	8	3	3.5	2	21	5								8	8
4	9	2	11	9	2	4	7.25	6	31	15	14	13	11	10				4	7.25
5	9	21	30	9	5	5	8	4	22	12	10	8						2	7.25
6	5	11	16	10	0	6	5	4	21	18	13	8						12	7
7	4	16	20	9	0	7	4.25	6	30	29	18	17	15	11				22	6.5
8	9	30	39	8	6	8	8	8	31	30	29	26	19	17	15	14		31	6
9	1	39	40	4	9	9	3.75	5	30	29	25	14	12					19	5.25
10	10	63	73	0	9	10	7.25	8	30	29	28	27	24	18	17	16		6	5
11	3	42	45	9	3	11	4.5	7	28	27	25	23	22	21	19			11	4.5
12	7	56	63	5	9	12	7	5	26	24	18	17	16					13	4.5
13	6	42	48	0	6	13	4.5	4	29	25	19	16						15	4.5
14	10	75	85	9	7	14	9	4	28	27	24	16						7	4.25
15	2	54	56	4	10	15	4.5	2	20	16								9	3.75
16	10	85	95	10	7	16	9.25	1	23									3	3.5
17	4	95	99	9	10	17	6.75	1	23									24	9.5
18	3	99	102	8	5	18	4.75	1	23									16	9.25
19	8	54	62	5	0	19	5.25	1	24									14	9
20	2	63	65	8	0	20	3	1	25									21	7.5
21	10	65	75	10	0	21	7.5	1	24									28	7.5
22	9	45	54	8	0	22	6.5	1	26									10	7.25
23	5	102	107	0	0	23	2.5	1	32									17	6.75
24	9	102	111	10	10	24	9.5	1	32									25	6.75
25	5	119	124	7	10	25	6.75	1	32									18	4.75
26	2	73	75	0	7	26	2.75	1	32									29	4.25
27	5	85	90	0	0	27	2.5	1	32									20	3
28	7	111	118	10	6	28	7.5	1	32									26	2.75
29	1	118	119	6	9	29	4.25	1	32									27	2.5
30	2	73	75	0	0	30	1	1	32									23	2.5
31	2	40	42	10	10	31	6	1	32									30	1
32	0	124	124	0	0	32	0	0											

Network 1105
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors											Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	9	2	3	4	5	6	7	9	14	15				
2	8	0	8	0	7	2	5.75	3	20	10	8									5	8.5
3	7	37	44	0	5	3	4.75	6	31	30	19	17	16	13						6	7.75
4	7	8	15	2	7	4	5.75	3	19	13	12									8	7.5
5	8	15	23	8	10	5	8.5	5	30	19	17	16	13							12	7
6	8	23	31	9	6	6	7.75	5	31	30	19	16	13							13	6
7	3	0	3	10	0	7	4	3	17	13	11									2	5.75
8	10	31	41	10	0	8	7.5	4	19	17	16	13								4	5.75
9	5	41	46	5	5	9	5	4	31	30	16	13								30	5.75
10	3	8	11	8	0	10	3.5	3	30	16	13									9	5
11	9	3	12	0	0	11	4.5	11	31	30	29	28	27	26	25	24	23	22	18	16	5
12	5	48	53	8	10	12	7	6	30	28	26	25	17	16						20	4.75
13	2	46	48	10	10	13	6	8	29	28	27	26	25	23	22	18				3	4.75
14	8	59	67	10	10	14	9	8	29	28	27	26	25	23	22	18				11	4.5
15	6	67	73	10	7	15	7.25	5	26	25	23	19	18							7	4
16	3	56	59	6	8	16	5	4	27	24	23	18								10	3.5
17	9	73	82	4	0	17	5.5	2	24	22										14	9
18	7	105	112	10	5	18	7.25	1	21											21	8.75
19	9	73	82	0	0	19	4.5	1	24											25	8.5
20	6	31	37	0	7	20	4.75	1	22											15	7.25
21	10	119	129	7	8	21	8.75	1	32											18	7.25
22	10	90	100	0	6	22	6.5	1	32											22	6.5
23	6	80	86	5	7	23	6	1	32											23	6
24	5	100	105	7	5	24	5.5	1	32											27	6
25	7	112	119	10	10	25	8.5	1	32											17	5.5
26	1	129	130	10	10	26	5.5	1	32											24	5.5
27	4	86	90	8	8	27	6	1	32											26	5.5
28	7	73	80	0	6	28	5	1	32											28	5
29	9	67	76	0	0	29	4.5	1	32											31	4.75
30	3	53	56	9	8	30	5.75	1	32											29	4.5
31	7	73	80	5	0	31	4.75	1	32											19	4.5
32	0	130	130	0	0	32	0	0													

Network 1112
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	6	2	3	5	6	7	9					
2	6	0	6	0	2	2	3.5	5	12	11	10	8	4					11	9
3	6	6	12	0	9	3	5.25	7	30	23	20	16	15	13	12			15	7.75
4	9	6	15	0	0	4	4.5	7	23	21	20	16	15	14	13			12	7
5	10	0	10	3	0	5	5.75	7	31	23	22	21	19	16	10			16	6.75
6	5	12	17	0	10	6	5	9	31	28	23	22	21	20	19	16	14	10	6.5
7	4	0	4	4	7	7	4.75	4	22	15	14	12						13	6.25
8	4	32	36	8	7	8	5.75	8	31	28	21	20	19	18	16	14		5	5.75
9	4	4	8	6	0	9	3.5	8	31	28	21	20	19	18	16	14		8	5.75
10	9	53	62	5	3	10	6.5	4	28	20	18	14						3	5.25
11	9	23	32	8	10	11	9	4	28	20	18	14						6	5
12	5	48	53	10	8	12	7	6	31	28	21	19	18	17				7	4.75
13	6	17	23	9	4	13	6.25	5	27	22	19	18	17					4	4.5
14	5	62	67	4	0	14	3.5	4	30	29	25	17						2	3.5
15	8	36	44	9	6	15	7.75	3	28	27	26							9	3.5
16	4	44	48	10	9	16	6.75	2	25	24								22	1
17	1	69	70	10	5	17	4.25	1	24									21	9.5
18	1	68	69	8	10	18	5	1	25									19	8
19	10	81	91	7	5	19	8	1	26									24	7.75
20	2	91	93	10	10	20	6	1	27									27	7.5
21	10	106	116	8	10	21	9.5	1	24									25	6.75
22	2	23	25	0	0	22	1	1	26									26	6.25
23	6	62	68	0	10	23	5.5	1	29									20	6
24	7	117	124	10	7	24	7.75	1	32									23	5.5
25	7	70	77	8	5	25	6.75	1	32									30	5.25
26	3	93	96	10	9	26	6.25	1	32									31	5.25
27	10	96	106	0	10	27	7.5	1	32									18	5
28	3	124	127	4	10	28	5	1	32									28	5
29	3	96	99	10	0	29	4	1	32									17	4.25
30	4	77	81	9	4	30	5.25	1	32									29	4
31	1	116	117	9	10	31	5.25	1	32									14	3.5
32	0	127	127	0	0	32	0	0											

Network 1119
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	7	2	4	5	7	9	12	15				
2	1	13	14	0	5	2	1.75	1	3									5	8.25
3	4	14	18	2	1	3	2.75	3	13	10	6							10	8.25
4	5	13	18	8	5	4	5.75	2	21	6								17	8.25
5	8	0	8	7	10	5	8.25	2	21	6								13	8
6	7	35	42	0	5	6	4.75	4	17	16	11	8						12	7.25
7	4	35	39	8	4	7	5	5	30	20	17	16	11					8	7
8	9	50	59	0	10	8	7	6	30	29	26	24	20	14				4	5.75
9	2	18	20	8	8	9	5	3	24	16	14							16	5.25
10	9	20	29	8	7	10	8.25	8	29	28	27	26	24	22	20	18		9	5
11	10	50	60	5	0	11	6.25	8	31	29	27	26	25	24	23	19		7	5
12	5	8	13	9	10	12	7.25	7	30	27	26	25	24	22	18			6	4.75
13	6	29	35	10	10	13	8	6	28	27	25	24	22	18				15	3.5
14	1	63	64	7	9	14	4.5	5	28	27	25	19	18					3	2.75
15	2	39	41	10	0	15	3.5	5	28	26	24	19	18					21	2.75
16	1	49	50	9	10	16	5.25	2	26	22								2	1.75
17	7	42	49	9	10	17	8.25	2	24	22								22	9.25
18	6	118	124	0	6	18	4.5	1	23									24	8.5
19	6	89	95	9	0	19	5.25	1	22									25	7.75
20	4	59	63	0	9	20	4.25	1	25									28	7
21	3	39	42	0	5	21	2.75	1	28									23	7
22	10	107	117	10	7	22	9.25	1	32									26	6.5
23	6	124	130	8	8	23	7	1	32									11	6.25
24	9	70	79	9	7	24	8.5	1	32									30	5.75
25	10	79	89	5	6	25	7.75	1	32									27	5.75
26	4	66	70	10	8	26	6.5	1	32									19	5.25
27	9	98	107	0	5	27	5.75	1	32									14	4.5
28	9	89	98	0	10	28	7	1	32									31	4.5
29	1	117	118	0	10	29	3	1	32									18	4.5
30	2	64	66	9	10	30	5.75	1	32									20	4.25
31	7	79	86	4	0	31	4.5	1	32									29	3
32	0	130	130	0	0	32	0	0											

Network 1127
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	8	2	3	4	5	6	7	8	9			
2	2	0	2	0	0	2	1	5	31	28	20	17	13					17	9
3	8	9	17	3	2	3	5.25	4	30	20	16	10						16	8.5
4	10	9	19	5	7	4	8	4	30	29	20	10						4	8
5	4	0	4	9	5	5	5.5	3	20	17	10							8	7.5
6	2	52	54	7	8	6	4.75	3	30	29	11							31	7.5
7	4	48	52	5	10	7	5.75	3	30	29	11							11	6.75
8	5	4	9	10	10	8	7.5	5	31	28	27	20	14					7	5.75
9	9	81	90	7	6	9	7.75	5	29	28	27	20	15					10	5.75
10	7	54	61	9	0	10	5.75	1	12									5	5.5
11	6	61	67	6	9	11	6.75	1	12									3	5.25
12	10	71	81	10	0	12	7.5	4	28	27	26	15						13	5.25
13	4	19	23	7	6	13	5.25	4	30	29	26	15						14	5
14	4	67	71	7	5	14	5	2	26	15								6	4.75
15	5	94	99	6	4	15	5	5	25	24	23	19	18					30	4.5
16	9	23	32	9	7	16	8.5	5	29	25	24	22	21					2	1
17	10	38	48	10	6	17	9	3	27	23	21							24	9
18	9	104	113	8	0	18	6.5	1	22									25	8.5
19	10	133	143	5	6	19	7.75	1	21									9	7.75
20	4	90	94	8	9	20	6.25	1	26									19	7.75
21	7	146	153	8	7	21	7.25	1	32									12	7.5
22	2	113	115	0	9	22	3.25	1	32									26	7.25
23	3	143	146	8	8	23	5.5	1	32									21	7.25
24	9	116	125	9	9	24	9	1	32									18	6.5
25	8	125	133	10	8	25	8.5	1	32									20	6.25
26	5	99	104	10	9	26	7.25	1	32									23	5.5
27	5	104	109	0	10	27	5	1	32									15	5
28	1	153	154	8	0	28	2.5	1	32									27	5
29	3	113	116	9	0	29	3.75	1	32									29	3.75
30	4	54	58	0	10	30	4.5	1	32									22	3.25
31	6	32	38	8	10	31	7.5	1	32									28	2.5
32	0	154	154	0	0	32	0	0											

Network 1200
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	2	2	4									
2	4	0	4	0	0	2	2	1	3									15	6
3	9	4	13	0	0	3	4.5	2	6	5								4	5.25
4	10	0	10	0	1	4	5.25	2	7	5								11	5.25
5	4	13	17	1	0	5	2.25	4	12	11	9	8						14	5
6	8	13	21	0	0	6	4	2	8	7								3	4.5
7	7	21	28	0	0	7	3.5	2	11	10								6	4
8	2	21	23	0	0	8	1	3	15	13	10							13	4
9	3	17	20	2	0	9	2	3	16	15	14							7	3.5
10	1	28	29	2	0	10	1	3	18	16	14							12	3
11	9	28	37	0	3	11	5.25	2	15	13								16	2.5
12	6	17	23	0	0	12	3	2	15	14								5	2.25
13	8	37	45	0	0	13	4	3	19	18	17							2	2
14	10	29	39	0	0	14	5	3	21	19	17							9	2
15	10	37	47	4	0	15	6	2	18	17								8	1
16	5	29	34	0	0	16	2.5	2	21	20								10	1
17	9	47	56	4	3	17	6.25	2	22	20								17	6.25
18	1	47	48	3	0	18	1.25	2	25	21								28	5
19	3	45	48	0	0	19	1.5	3	25	23	22							30	5
20	7	56	63	0	1	20	3.75	4	27	25	24	23						25	4.75
21	8	48	56	0	0	21	4	2	23	22								23	4.25
22	7	56	63	2	0	22	4	3	27	26	24							26	4.25
23	7	63	70	2	1	23	4.25	2	28	26								21	4
24	3	63	66	5	0	24	2.75	3	31	30	28							22	4
25	8	63	71	2	1	25	4.75	3	31	30	28							20	3.75
26	5	70	75	3	4	26	4.25	3	31	30	29							29	3.75
27	3	63	66	1	4	27	2.75	1	28									24	2.75
28	8	71	79	4	0	28	5	1	29									27	2.75
29	7	79	86	1	0	29	3.75	1	32									19	1.5
30	8	75	83	0	4	30	5	1	32									18	1.25
31	1	75	76	0	0	31	0.5	1	32									31	0.5
32	0	86	86	0	0	32	0	0											

Network 1201
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

(yellow) Low Level of Stochastic Tasks Occurs Early in Schedule
(light blue) High Level of Stochastic Tasks Occurs Early in Schedule
(purple) Low Level of Stochastic Tasks Occurs Late in Schedule
(orange) High Level of Stochastic Tasks Occurs Late in Schedule

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors				Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	4	2	3	4	6		
2	10	0	10	0	0	2	5	3	11	7	5		2	5
3	3	0	3	1	0	3	1.75	4	11	10	8	7	5	4
4	2	0	2	3	1	4	2	4	14	11	10	8	13	3.5
5	8	10	18	0	0	5	4	3	14	10	8		14	3.25
6	4	0	4	3	0	6	2.75	3	11	10	8		6	2.75
7	3	10	13	2	2	7	2.5	2	14	9			7	2.5
8	3	18	21	3	0	8	2.25	1	9				11	2.25
9	2	21	23	2	0	9	1.5	3	15	13	12		8	2.25
10	3	18	21	0	0	10	1.5	2	13	12			12	2.25
11	2	10	12	5	0	11	2.25	2	15	12			4	2
12	3	23	26	3	0	12	2.25	3	18	17	16		3	1.75
13	7	23	30	0	0	13	3.5	3	18	17	16		18	1.75
14	5	18	23	3	0	14	3.25	3	19	18	17		10	1.5
15	1	23	24	0	0	15	0.5	3	21	19	18		9	1.5
16	6	30	36	0	0	16	3	2	21	19			15	0.5
17	10	30	40	0	2	17	5.5	3	22	21	20		25	6
18	3	30	33	0	1	18	1.75	3	24	23	22		17	5.5
19	9	36	45	0	3	19	5.25	2	22	20			19	5.25
20	5	45	50	2	3	20	3.75	3	26	25	24		30	5
21	1	40	41	0	3	21	1.25	2	26	23			20	3.75
22	6	45	51	2	0	22	3.5	2	26	25			23	3.75
23	7	41	48	1	0	23	3.75	2	27	25			22	3.5
24	7	50	57	0	0	24	3.5	2	29	27			24	3.5
25	8	51	59	3	5	25	6	2	29	28			28	3.25
26	1	51	52	0	0	26	0.5	2	31	227			16	3
27	4	57	61	0	0	27	2	1	28				31	2.5
28	5	61	66	3	0	28	3.25	1	30				27	2
29	3	59	62	0	0	29	1.5	1	31				29	1.5
30	9	66	75	0	2	30	5	1	32				21	1.25
31	5	62	67	0	0	31	2.5	1	32				26	0.5
32	0	75	75	0	0	32	0	0						

Network 1212
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors			Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	5	6		
2	10	0	10	0	0	2	5	2	4	3		11	6.25
3	2	10	12	0	0	3	1	3	9	8	7	10	5.25
4	9	10	19	0	1	4	4.75	3	12	9	8	2	5
5	1	0	1	1	0	5	0.75	3	10	9	7	4	4.75
6	8	0	8	0	0	6	4	3	13	12	8	7	4.5
7	8	12	20	2	0	7	4.5	3	14	13	12	12	4.25
8	4	19	23	0	0	8	2	2	14	10		6	4
9	4	19	23	1	0	9	2.25	2	13	11		14	4
10	10	23	33	1	0	10	5.25	1	11			13	3
11	10	33	43	3	2	11	6.25	3	17	16	15	9	2.25
12	7	20	27	3	0	12	4.25	2	16	15		17	2.25
13	6	23	29	0	0	13	3	2	19	17		8	2
14	8	23	31	0	0	14	4	2	19	16		3	1
15	7	43	50	0	3	15	4.25	3	20	19	18	16	1
16	2	43	45	0	0	16	1	2	20	18		5	0.75
17	3	43	46	3	0	17	2.25	2	20	18		18	6.5
18	10	50	60	1	5	18	6.5	3	23	22	21	30	5.75
19	9	50	59	0	0	19	4.5	3	24	23	22	23	5.25
20	1	50	51	1	3	20	1.5	2	23	21		25	5.25
21	5	60	65	0	0	21	2.5	3	26	25	24	22	5
22	8	60	68	4	0	22	5	3	29	26	25	19	4.5
23	8	60	68	4	1	23	5.25	2	29	25		15	4.25
24	3	65	68	0	1	24	1.75	3	29	28	27	27	3.75
25	9	68	77	3	0	25	5.25	2	28	27		31	3.5
26	2	68	70	1	0	26	1.25	2	31	27		28	3
27	5	77	82	5	0	27	3.75	1	30			21	2.5
28	3	77	80	2	4	28	3	1	30			29	2.25
29	2	68	70	4	1	29	2.25	1	31			24	1.75
30	8	82	90	3	4	30	5.75	1	32			20	1.5
31	7	70	77	0	0	31	3.5	1	32			26	1.25
32	0	90	90	0	0	32	0	0					

Network 1222
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors			Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	4		
2	9	0	9	0	1	2	4.75	2	6	5		12	5
3	4	0	4	1	0	3	2.25	3	9	7	6	2	4.75
4	7	0	7	0	0	4	3.5	3	9	7	6	8	4.5
5	1	9	10	4	4	5	2.5	3	12	9	7	10	4
6	6	9	15	0	1	6	3.25	3	12	11	8	13	3.75
7	2	10	12	3	0	7	1.75	2	11	10		4	3.5
8	7	15	22	0	4	8	4.5	2	15	10		11	3.5
9	6	10	16	0	0	9	3	3	19	15	14	6	3.25
10	8	22	30	0	0	10	4	2	14	13		9	3
11	6	15	21	2	0	11	3.5	2	15	13		5	2.5
12	9	15	24	2	0	12	5	2	14	13		3	2.25
13	6	30	36	2	1	13	3.75	2	19	16		7	1.75
14	1	30	31	2	2	14	1.5	2	17	16		14	1.5
15	2	22	24	0	0	15	1	2	18	17		15	1
16	1	36	37	3	1	16	1.5	2	21	18		17	1
17	2	31	33	0	0	17	1	2	21	20		24	6.5
18	2	37	39	3	0	18	1.75	2	23	20		27	5.75
19	3	36	39	3	4	19	3.25	3	31	24	23	30	5.75
20	3	39	42	3	2	20	2.75	2	26	22		28	5.75
21	10	37	47	2	0	21	5.5	2	31	23		21	5.5
22	1	42	43	0	1	22	0.75	3	31	25	24	29	3.75
23	2	47	49	0	0	23	1	2	26	25		25	3.5
24	10	43	53	3	3	24	6.5	3	30	29	27	19	3.25
25	7	49	56	0	0	25	3.5	3	30	29	28	31	3.25
26	6	49	55	0	0	26	3	2	29	27		26	3
27	10	55	65	3	0	27	5.75	1	28			20	2.75
28	10	65	75	0	3	28	5.75	1	32			18	1.75
29	7	56	63	1	0	29	3.75	1	32			16	1.5
30	10	56	66	3	0	30	5.75	1	32			23	1
31	4	47	51	2	3	31	3.25	1	32			22	0.75
32	0	75	75	0	0	32	0	0					

Network 1225
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors				Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	5			
2	1	0	1	0	1	2	0.75	2	6	4			13	5.75
3	2	0	2	0	0	3	1	1	4				12	5.25
4	1	2	3	0	8	4	2.5	3	11	9	7		6	5
5	8	0	8	1	0	5	4.25	3	11	9	8		7	4.75
6	9	1	10	1	1	6	5	3	11	10	8		14	4.75
7	8	3	11	0	3	7	4.75	2	10	8			5	4.25
8	8	11	19	0	0	8	4	3	14	13	12		8	4
9	4	8	12	3	0	9	2.75	2	14	10			17	4
10	1	12	13	0	0	10	0.5	2	15	13			9	2.75
11	4	10	14	0	0	11	2	2	14	13			4	2.5
12	10	19	29	0	1	12	5.25	3	17	16	15		15	2.25
13	9	19	28	3	2	13	5.75	3	18	17	16		11	2
14	6	19	25	4	3	14	4.75	2	18	16			3	1
15	4	29	33	1	0	15	2.25	3	20	19	18		2	0.75
16	10	29	39	4	0	16	6	2	20	19			10	0.5
17	7	29	36	1	1	17	4	3	23	21	20		30	6.75
18	3	33	36	2	0	18	2	4	24	23	22	21	16	6
19	5	39	44	0	1	19	2.75	4	27	23	22	21	24	5
20	6	39	45	1	0	20	3.25	3	26	24	22		25	4
21	3	44	47	3	0	21	2.25	3	31	26	25		20	3.25
22	5	45	50	2	1	22	3.25	2	31	25			22	3.25
23	1	44	45	0	2	23	1	2	26	25			28	3
24	10	45	55	0	0	24	5	2	27	25			29	3
25	6	55	61	4	0	25	4	2	30	28			19	2.75
26	4	47	51	0	0	26	2	2	30	29			27	2.75
27	5	55	60	0	1	27	2.75	1	28				31	2.5
28	4	61	65	0	4	28	3	1	29				21	2.25
29	5	65	70	2	0	29	3	1	32				18	2
30	9	61	70	5	4	30	6.75	1	32				26	2
31	3	50	53	0	4	31	2.5	1	32				23	1
32	0	70	70	0	0	32	0	0						

Network 1300
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors				Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	2	2	5				
2	5	0	5	0	0	2	2.5	3	6	4	3		9	9.5
3	7	5	12	0	4	3	4.5	4	13	9	8	7	7	9.25
4	5	5	10	5	6	4	5.25	3	13	9	7		11	9
5	1	0	1	5	7	5	3.5	3	13	9	8		18	8.75
6	6	10	16	9	5	6	6.5	3	13	11	10		6	6.5
7	9	29	38	10	9	7	9.25	2	11	10			15	6.25
8	3	26	29	10	7	8	5.75	2	11	10			8	5.75
9	10	16	26	8	10	9	9.5	2	14	11			4	5.25
10	6	48	54	0	8	10	5	3	15	14	12		13	5
11	10	38	48	8	8	11	9	2	15	12			10	5
12	8	54	62	0	0	12	4	3	18	17	16		14	4.75
13	5	48	53	10	0	13	5	3	18	16	15		3	4.5
14	6	54	60	0	7	14	4.75	4	24	19	18	17	12	4
15	6	60	66	6	7	15	6.25	3	24	20	19		5	3.5
16	1	75	76	6	10	16	4.5	3	24	21	19		2	2.5
17	6	76	82	10	7	17	7.25	3	22	20			24	9.5
18	9	66	75	7	10	18	8.75	3	23	22	21		17	7.25
19	3	82	85	9	5	19	5	2	23	22			26	7
20	2	85	87	0	9	20	3.25	1	23	21			28	7
21	8	87	95	0	0	21	4	1	27	26	25		27	6
22	3	85	88	10	0	22	4	2	27	26	25		19	5
23	2	98	100	6	9	23	4.75	1	31	27	26		29	5
24	10	88	98	10	8	24	9.5	2	26	25			23	4.75
25	3	100	103	6	7	25	4.75	3	31	30	28		25	4.75
26	10	103	113	0	8	26	7	2	30	28			16	4.5
27	5	117	122	6	8	27	6	3	28				22	4
28	9	122	131	5	5	28	7	3	29				21	4
29	5	131	136	0	10	29	5	1	32				30	3.5
30	2	113	115	10	0	30	3.5	1	32				31	3.5
31	4	113	117	0	6	31	3.5	2	32				20	3.25
32	0	136	136	0	0	32	0	0						

Network 1304
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors			Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	4		
2	7	0	7	0	0	2	3.5	3	8	6	5	14	8.75
3	3	8	11	1	3	3	2.5	3	8	7	5	4	8.5
4	8	0	8	10	8	4	8.5	3	11	8	7	10	8.25
5	6	18	24	9	8	5	7.25	3	12	11	9	6	7.5
6	7	11	18	8	8	6	7.5	3	12	11	10	12	7.5
7	2	25	27	7	3	7	3.5	2	12	9		5	7.25
8	1	24	25	7	9	8	4.5	3	15	12	10	9	6.25
9	3	27	30	9	10	9	6.25	2	15	10		15	6
10	10	30	40	6	7	10	8.25	2	14	13		16	6
11	5	40	45	0	6	11	4	2	15	13		8	4.5
12	10	40	50	10	0	12	7.5	2	17	14		13	4.25
13	5	45	50	0	7	13	4.25	2	17	16		11	4
14	8	50	58	9	10	14	8.75	3	20	19	16	2	3.5
15	7	58	65	0	10	15	6	2	20	18		7	3.5
16	7	58	65	10	0	16	6	2	22	18		3	2.5
17	1	65	66	9	0	17	2.75	2	20	19		20	9.5
18	5	65	70	0	6	18	4	3	25	23	21	31	9.5
19	3	80	83	4	8	19	4.5	3	25	24	23	26	7.5
20	10	70	80	9	9	20	9.5	2	23	22		27	7.25
21	1	83	84	10	0	21	3	3	28	27	24	28	6.5
22	4	83	87	0	5	22	3.25	2	27	24		29	6
23	1	93	94	0	8	23	2.5	2	28	26		24	5
24	4	87	91	8	4	24	5	1	26			19	4.5
25	6	87	93	0	6	25	4.5	1	27			25	4.5
26	6	102	108	8	10	26	7.5	2	31	29		30	4.5
27	8	94	102	6	7	27	7.25	2	31	29		18	4
28	9	108	117	0	8	28	6.5	1	29			22	3.25
29	4	117	121	6	10	29	6	1	30			21	3
30	9	121	130	0	0	30	4.5	1	32			17	2.75
31	9	121	130	10	10	31	9.5	1	32			23	2.5
32	0	130	130	0	0	32	0	0					

Network 1308
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

	Early Schedule Low Level
	Early Schedule High Level
	Late Schedule Low Level
	Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	5								
2	3	0	3	0	3	2	2.25	2	7	4								11	9.75
3	4	3	7	0	10	3	4.5	4	9	8	7	6						14	8.75
4	6	7	13	0	9	4	5.25	3	9	8	6							13	8.5
5	6	0	6	3	0	5	3.75	3	9	7	6							10	7.25
6	7	19	26	8	5	6	6.75	3	13	11	10							12	7
7	2	7	9	10	0	7	3.5	3	13	11	10							6	6.75
8	4	26	30	10	0	8	4.5	2	11	10								9	6.5
9	6	13	19	4	10	9	6.5	2	13	11								16	6.5
10	10	37	47	0	9	10	7.25	2	16	12								4	5.25
11	10	47	57	9	10	11	9.75	3	16	15	14							3	4.5
12	10	57	67	0	8	12	7	3	22	15	14							8	4.5
13	7	30	37	10	10	13	8.5	2	16	14								5	3.75
14	10	68	78	7	8	14	8.75	3	19	18	17							7	3.5
15	7	78	85	6	5	15	6.25	3	19	18	17							2	2.25
16	9	57	66	8	0	16	6.5	3	22	21	20							22	2
17	6	87	93	6	7	17	6.25	2	21	20								21	9.5
18	7	93	100	0	9	18	5.75	2	26	21								28	9.5
19	2	85	87	10	6	19	5	3	26	24	23							15	6.25
20	4	100	104	9	6	20	5.75	3	26	25	24							17	6.25
21	10	104	114	10	8	21	9.5	2	24	23								18	5.75
22	1	67	68	0	6	22	2	2	26	24								20	5.75
23	1	120	121	10	8	23	5	3	30	27	25							31	5.75
24	6	114	120	7	3	24	5.5	3	30	28	27							24	5.5
25	4	125	129	9	5	25	5.5	3	31	29	28							25	5.5
26	4	121	125	0	9	26	4.25	3	31	30	28							19	5
27	7	121	128	0	0	27	3.5	1	29									23	5
28	9	129	138	10	10	28	9.5	1	32									30	4.75
29	4	141	145	0	6	29	3.5	1	32									26	4.25
30	8	138	146	3	0	30	4.75	1	32									27	3.5
31	3	138	141	7	10	31	5.75	1	32									29	3.5
32	0	146	146	0	0	32	0	0											

Network 1314
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors				Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	6			
2	3	0	3	0	6	2	3	2	5	4			11	9.5
3	5	0	5	2	0	3	3	2	7	5			12	9.25
4	5	3	8	8	7	4	6.25	3	12	11	7		10	7.75
5	2	5	7	0	0	5	1	3	12	11	8		9	7.5
6	3	8	11	5	6	6	4.25	3	12	11	8		7	7
7	6	11	17	10	6	7	7	2	9	8			4	6.25
8	4	27	31	0	5	8	3.25	2	14	10			13	5.5
9	6	31	37	10	8	9	7.5	4	16	15	14	13	6	4.25
10	7	37	44	7	10	10	7.75	3	16	15	13		16	4.25
11	10	17	27	9	9	11	9.5	2	14	13			18	4
12	9	44	53	10	9	12	9.25	3	18	17	16		14	3.75
13	3	53	56	6	10	13	5.5	3	19	18	17		8	3.25
14	2	56	58	5	6	14	3.75	3	19	18	17		2	3
15	1	62	63	10	0	15	3	3	21	19	17		3	3
16	6	56	62	5	0	16	4.25	3	21	20	19		5	1
17	6	65	71	7	0	17	4.75	2	22	20			19	9.25
18	3	58	61	0	10	18	4	2	25	21			24	7.5
19	10	71	81	8	9	19	9.25	3	25	23	22		28	7
20	2	81	83	8	10	20	5.5	3	25	24	23		30	6
21	2	63	65	6	9	21	4.75	2	23	22			20	5.5
22	8	83	91	0	6	22	5.5	3	31	27	24		22	5.5
23	6	83	89	10	0	23	5.5	3	31	27	26		23	5.5
24	10	95	105	10	0	24	7.5	2	28	26			29	5.5
25	1	95	96	0	10	25	3	2	30	27			17	4.75
26	1	105	106	10	5	26	4.25	2	30	29			21	4.75
27	3	106	109	5	8	27	4.75	1	28				27	4.75
28	5	113	118	10	8	28	7	1	29				31	4.5
29	4	118	122	9	5	29	5.5	1	32				26	4.25
30	4	109	113	10	6	30	6	1	32				15	3
31	4	91	95	6	4	31	4.5	1	32				25	3
32	0	122	122	0	0	32	0	0						

Network 1325
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	R1 Utilization	R2 Utilization	Activity Number	SN	Number of Successors	Successors									Selection of Stochastic Tasks	
1	0	0	0	0	0	1	0	3	2	3	5								
2	5	0	5	0	3	2	3.25	3	7	6	4							8	8.5
3	10	0	10	0	0	3	5	2	7	4								11	8.5
4	3	10	13	0	9	4	3.75	4	11	10	9	8						9	8
5	6	0	6	4	7	5	5.75	3	11	9	7							6	6.5
6	8	6	14	10	0	6	6.5	2	10	8								10	6.5
7	2	14	16	5	6	7	3.75	2	12	10								5	5.75
8	9	16	25	6	10	8	8.5	2	14	12								12	5.25
9	8	32	40	8	8	9	8	2	14	12								3	5
10	7	25	32	4	8	10	6.5	2	14	13								14	4.25
11	8	40	48	8	10	11	8.5	2	16	12								15	4
12	7	51	58	0	7	12	5.25	2	15	13								4	3.75
13	3	58	61	0	6	13	3	3	21	20	17							7	3.75
14	3	48	51	5	6	14	4.25	2	16	15								2	3.25
15	8	58	66	0	0	15	4	3	21	19	18							16	3.25
16	1	61	62	3	8	16	3.25	3	24	21	18							13	3
17	7	62	69	10	9	17	8.25	2	19	18								30	9.25
18	2	76	78	10	7	18	5.25	2	23	22								25	9
19	1	78	79	0	8	19	2.5	2	24	23								28	9
20	7	69	76	9	9	20	8	2	23	22								29	8.5
21	5	79	84	9	7	21	6.5	1	22									17	8.25
22	7	87	94	10	4	22	7	3	27	26	25							20	8
23	3	84	87	7	4	23	4.25	3	31	27	25							27	8
24	3	94	97	9	10	24	6.25	2	26	25								22	7
25	8	103	111	10	10	25	9	2	29	28								31	6.75
26	4	111	115	6	6	26	5	2	31	30								21	6.5
27	6	97	103	10	10	27	8	1	28									24	6.25
28	10	115	125	8	8	28	9	1	30									18	5.25
29	7	132	139	10	10	29	8.5	1	30									26	5
30	10	139	149	8	9	30	9.25	1	32									23	4.25
31	7	125	132	10	3	31	6.75	1	32									19	2.5
32	0	149	149	0	0	32	0	0											

APPENDIX D
RANGEN AND DH ALGORITHM RAW DATA OUTPUT FILES FOR SELIM (2002) BUFFER APPROACH

The research conducted in this dissertation resulted in several data files that were too large to effectively be inserted directly into the document. To preserve the integrity and usability of the data, direct links to the pdf versions of the files have been established in the appendices. The subject appendices each contain tables with links, found in the left-most column, that bring up the specified file. The user will then simply scroll to the desired page, as specified in the table cells.

The table on the following page contains the links to the RanGen and DH output Raw Data for the Pessimistic, Optimistic, and Perfect Knowledge Schedules studied in Selim (2002).

Note: the RanGen output data file format is the required data file input format for the DH Algorithm.

Legend:

P = Pessimistic Schedule

OL = Optimistic Schedule with a Low Level of Stochasticity

OH = Optimistic Schedule with a High Level of Stochasticity

LL = Perfect Knowledge Schedule with a Low Level of Stochasticity Occurring Late in Schedule

EL = Perfect Knowledge Schedule with a Low Level of Stochasticity Occurring Early in Schedule

LH = Perfect Knowledge Schedule with a High Level of Stochasticity Occurring Late in Schedule

EH = Perfect Knowledge Schedule with a High Level of Stochasticity Occurring Early in Schedule

	RANGEN OUTPUT RAW DATA							**DH OUTPUT RAW DATA**						
Network	**P**	**OL**	**OH**	**LL**	**EL**	**LH**	**EH**	**P**	**OL**	**OH**	**LL**	**EL**	**LH**	**EH**
1004	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1010	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1015	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1020	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1028	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1102	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1105	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1112	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1119	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1127	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1200	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1201	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1212	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1222	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1225	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1300	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1304	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1308	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1314	2	4	6	8	10	12	14	3	5	7	9	11	13	15
1325	2	4	6	8	10	12	14	3	5	7	9	11	13	15

APPENDIX E
JG PARTIAL BUFFER CALCULATONS

The links below contained the detailed calculations for the JG3, JG4, JG5 and JG5 partial buffer calculations. JG3 and JG4 are based on the sequential sequence of tasks. JG5 and JG6 are based on the optimal sequence of tasks.

Partial Buffer Calculations			
Network 1004	**Page 45 & 46**	**Network 1200**	**Page 45 & 46**
Network 1010	**Page 45 & 46**	**Network 1201**	**Page 45 & 46**
Network 1015	**Page 45 & 46**	**Network 1212**	**Page 45 & 46**
Network 1020	**Page 45 & 46**	**Network 1222**	**Page 45 & 46**
Network 1028	**Page 45 & 46**	**Network 1225**	**Page 45 & 46**
Network 1102	**Page 45 & 46**	**Network 1300**	**Page 45 & 46**
Network 1105	**Page 45 & 46**	**Network 1304**	**Page 45 & 46**
Network 1112	**Page 45 & 46**	**Network 1308**	**Page 45 & 46**
Network 1119	**Page 45 & 46**	**Network 1314**	**Page 45 & 46**
Network 1127	**Page 45 & 46**	**Network 1325**	**Page 45 & 46**

APPENDIX F
RANGEN AND DH ALGORITHM RAW DATA OUTPUT FILES FOR PARTIAL BUFFER APPROACH

The links in the following two tables provide the RanGen and DH algorithm output data for the 10%, 30% and 50% fixed partial buffering approaches and the JG3, JG4, JG5 and JG6 variable partial buffering approaches.

Note: the RanGen output data file format is the required data file input format for the DH Algorithm.

Legend:

10 L = 10% partial buffer at low level of stochasticity

10 H = 10% partial buffer at high level of stochasticity

30 L = 30% partial buffer at low level of stochasticity

30 H = 30% partial buffer at high level of stochasticity

50 L = 50% partial buffer at low level of stochasticity

50 H = 50% partial buffer at high level of stochasticity

JG3 L = JG3 Partial buffer at low level of stochasticity

JG3 H = JG3 Partial buffer at high level of stochasticity

JG4 L = JG3 Partial buffer at low level of stochasticity

JG4 H = JG3 Partial buffer at high level of stochasticity

JG5 L = JG3 Partial buffer at low level of stochasticity

JG5 H = JG3 Partial buffer at high level of stochasticity

JG6 L = JG3 Partial buffer at low level of stochasticity

JG6 H = JG3 Partial buffer at high level of stochasticity

	Fixed Buffer Size											
	RanGen Output Data						DH Output Data					
Network	**10L**	**10H**	**30L**	**30H**	**50L**	**50H**	**10L**	**10H**	**30L**	**30H**	**50L**	**50H**
1004	16	30	18	32	20	34	17	31	19	33	21	35
1010	16	30	18	32	20	34	17	31	19	33	21	35
1015	16	30	18	32	20	34	17	31	19	33	21	35
1020	16	30	18	32	20	34	17	31	19	33	21	35
1028	16	30	18	32	20	34	17	31	19	33	21	35
1102	16	30	18	32	20	34	17	31	19	33	21	35
1105	16	30	18	32	20	34	17	31	19	33	21	35
1112	16	30	18	32	20	34	17	31	19	33	21	35
1119	16	30	18	32	20	34	17	31	19	33	21	35
1127	16	30	18	32	20	34	17	31	19	33	21	35
1200	16	30	18	32	20	34	17	31	19	33	21	35
1201	16	30	18	32	20	34	17	31	19	33	21	35
1212	16	30	18	32	20	34	17	31	19	33	21	35
1222	16	30	18	32	20	34	17	31	19	33	21	35
1225	16	30	18	32	20	34	17	31	19	33	21	35
1300	16	30	18	32	20	34	17	31	19	33	21	35
1304	16	30	18	32	20	34	17	31	19	33	21	35
1308	16	30	18	32	20	34	17	31	19	33	21	35
1314	16	30	18	32	20	34	17	31	19	33	21	35
1325	16	30	18	32	20	34	17	31	19	33	21	35

	JG3 and JG4 Variable Partial Buffers							
	RanGen Output Data				DH Output Data			
Network	**JG3L**	**JG3H**	**JG4L**	**JG4H**	**JG3L**	**JG3H**	**JG4L**	**JG4H**
1004	22	36	24	38	23	37	25	39
1010	22	36	24	38	23	37	25	39
1015	22	36	24	38	23	37	25	39
1020	22	36	24	38	23	37	25	39
1028	22	36	24	38	23	37	25	39
1102	22	36	24	38	23	37	25	39
1105	22	36	24	38	23	37	25	39
1112	22	36	24	38	23	37	25	39
1119	22	36	24	38	23	37	25	39
1127	22	36	24	38	23	37	25	39
1200	22	36	24	38	23	37	25	39
1201	22	36	24	38	23	37	25	39
1212	22	36	24	38	23	37	25	39
1222	22	36	24	38	23	37	25	39
1225	22	36	24	38	23	37	25	39
1300	22	36	24	38	23	37	25	39
1304	22	36	24	38	23	37	25	39
1308	22	36	24	38	23	37	25	39
1314	22	36	24	38	23	37	25	39
1325	22	36	24	38	23	37	25	39

	JG5 and JG6 Variable Partial Buffers							
	RanGen Output Data				DH Output Data			
Network	JG5L	JG5H	JG6L	JG6H	JG5L	JG5H	JG6L	JG6H
1004	26	40	28	42	27	41	29	43
1010	26	40	28	42	27	41	29	43
1015	26	40	28	42	27	41	29	43
1020	26	40	28	42	27	41	29	43
1028	26	40	28	42	27	41	29	43
1102	26	40	28	42	27	41	29	43
1105	26	40	28	42	27	41	29	43
1112	26	40	28	42	27	41	29	43
1119	26	40	28	42	27	41	29	43
1127	26	40	28	42	27	41	29	43
1200	26	40	28	42	27	41	29	43
1201	26	40	28	42	27	41	29	43
1212	26	40	28	42	27	41	29	43
1222	26	40	28	42	27	41	29	43
1225	26	40	28	42	27	41	29	43
1300	26	40	28	42	27	41	29	43
1304	26	40	28	42	27	41	29	43
1308	26	40	28	42	27	41	29	43
1314	26	40	28	42	27	41	29	43
1325	26	40	28	42	27	41	29	43

APPENDIX G
RANGEN INPUT VALUE SUMMARY CHARTS

Yellow	Early Schedule Low Level
Light cyan	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1004

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	0.60	0.59
3	3.5	6	0	0	6	6	0	0	0.6	1.8	3	0.09	0.31	0.38	0.53	0.6	1.8	3	0.05	0.17	0.38	0.30
4	4.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.60	2.64	4.50	0.9	2.7	4.5	0.07	0.33	2.64	2.95
5	6.5	10	0	0	10	10	0	0	1	3	5	0.15	0.96	2.19	3.68	1	3	5	0.08	0.53	2.19	2.54
6	2.5	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.10	1.69	1.84
7	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	5.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.73	1.41	1.99	0.9	2.7	4.5	0.07	0.41	1.41	1.55
10	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	5	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10	0.51	3.59	4.22	0.7	2.1	3.5	0.06	0.29	3.59	3.56
14	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
16	5	8	0	0	0	0	8	8	0.8	2.4	4	0.12	0.59	6.65	6.94	0.8	2.4	4	0.07	0.33	6.65	6.36
17	3.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	4	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	4.50	4.59
20	2.5	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.03	0.08	1.68	1.80
21	5.75	10	0	0	0	0	10	10	1	3	5	0.15	0.85	6.25	7.50	1	3	5	0.08	0.47	6.25	6.56
22	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
23	5.75	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	0.76	7.99	9.00	0.9	2.7	4.5	0.07	0.42	7.99	7.82
24	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
25	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	4.5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.30	8.00	8.00
27	5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.33	7.50	7.48
28	4.75	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.07	0.35	6.19	6.57
29	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	2.25	2.51
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- Early Schedule Low Level (yellow)
- Early Schedule High Level (light blue)
- Late Schedule Low Level (purple)
- Late Schedule High Level (orange)

Network 1010

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules																	
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	1.64	1.06
3	3.5	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.20	2.23	1.91
4	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	4.25	8	0	0	8	8	0	0	0.8	2.4	4	0.12	0.49	1.22	0.93	0.8	2.4	4	0.07	0.28	1.22	0.53
6	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	6	10	0	0	10	10	0	0	1	3	5	0.14	0.87	2.72	2.32	1	3	5	0.08	0.50	2.72	2.15
8	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	5	8	0	0	8	8	0	0	0.8	2.4	4	0.12	0.58	3.92	3.71	0.8	2.4	4	0.07	0.33	3.92	3.64
12	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	4.34	4.17
13	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	3.75	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.19	2.62	2.33
15	5.5	8	0	0	8	8	0	0	0.8	2.4	4	0.12	0.64	3.18	2.78	0.8	2.4	4	0.07	0.36	3.18	2.71
16	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	2.75	2	2	0	2	0	2	2	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.05	1.51	1.52
18	4.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.25	5.05	5.21
19	2.75	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	3.25	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.16	4.85	4.86
21	4	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	7.58	7.54
22	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	4.5	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10	0.46	6.95	6.80	0.7	2.1	3.5	0.06	0.26	6.95	7.00
26	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	5	8	0	0	0	0	8	8	0.8	2.4	4	0.12	0.58	7.10	6.96	0.8	2.4	4	0.07	0.33	7.10	7.01
30	6.75	10	0	0	0	0	10	10	1	3	5	0.14	0.98	6.75	7.54	1	3	5	0.08	0.56	6.75	6.86
31	5	10	0	0	0	0	10	10	1	3	5	0.14	0.72	6.09	6.09	1	3	5	0.08	0.41	6.09	6.03
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1015

RCP Input Files: Project Task Duration Times

		Perfect Knowledge Schedules																				
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.75	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.22	0.94	0.69
3	4.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13433	0.60448	2.06145	2.28358	0.9	2.7	4.5	0.07377	0.331967	2.06145	2.1393
4	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	3	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.12	0.47	0.20
7	4.5	8	0	0	8	8	0	0	0.8	2.4	4	0.1194	0.53731	1.43017	0.95522	0.8	2.4	4	0.07	0.30	1.43	1.31
8	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13433	0.67164	2.51397	3.49254	0.9	2.7	4.5	0.07377	0.368852	2.51397	2.8033
13	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	2.68	2.95
14	1.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
16	5.5	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10448	0.57463	3.67598	4.49254	0.7	2.1	3.5	0.05738	0.315574	3.67598	3.8443
17	5	10	0	0	10	10	0	0	1	3	5	0.15	0.75	3.35	5.37	1	3	5	0.08	0.41	3.35	3.93
18	4.75	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10448	0.49627	5.78771	5.22388	0.7	2.1	3.5	0.05738	0.272541	5.78771	5.5656
19	4.75	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	0.64	8.30	7.93	0.9	2.7	4.5	0.07	0.35	8.30	8.41
20	4.5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.30	4.56	4.92
21	4.5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.06557	0.295082	4.9162	5.4426
22	6	8	0	0	0	0	8	8	0.8	2.4	4	0.1194	0.71642	8	8	0.8	2.4	4	0.07	0.39	8.00	8.00
23	3.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
24	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
25	4	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.26	6.97	6.89
26	2.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
27	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
28	4.5	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.05738	0.258197	4.73184	5.1639
29	3.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
30	3.5	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.17	2.48	2.66
31	3.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1020

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules																	
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.5	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.19	0.76	0.67
3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	4.75	8	0	0	8	8	0	0	0.8	2.4	4	0.11	0.54	1.24	0.90	0.8	2.4	4	0.06	0.30	1.24	1.27
6	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7	3.25	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.13	0.34	0.20
8	4.75	8	0	0	8	8	0	0	0.8	2.4	4	0.11	0.54	3.22	3.61	0.8	2.4	4	0.06	0.30	3.22	3.68
9	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	4.25	7	0	0	7	7	0	0	0.7	2.1	3.5	0.10	0.42	1.53	1.48	0.7	2.1	3.5	0.06	0.236	1.53	1.5
11	3.5	7	7	0	7	7	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.19	2.17	2.39
12	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
15	5	#	0	0	0	0	10	10	1	3	5	0.14	0.70	4.60	5.92	1	3	5	0.08	0.397	4.6	5.4
16	4	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.222	2.49	2.78
17	2.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
18	4.75	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.226	3.59	3.95
19	5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.63	2.43	3.04	0.9	2.7	4.5	0.07	0.36	2.43	2.57
20	3.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
21	5.5	#	0	0	0	0	10	10	1	3	5	0.14	0.77	7.93	8.73	1	3	5	0.08	0.437	7.93	8.73
22	4.5	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.25	5.15	5.56
23	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
24	3.25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
25	3.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
26	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	4	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.222	7	7
28	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	5.5	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	0.70	8.12	9.00	0.9	2.7	4.5	0.07	0.393	8.12	8.5
30	4.75	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.07	0.34	4.86	5.50
31	7.25	#	0	0	0	0	10	10	1	3	5	0.14	1.02	6.55	7.32	1	3	5	0.08	0.575	6.55	7.38
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Legend
Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Network 1028

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4.25	8	0	0	8	8	0	0	0.8	2.4	4	0.11	0.50	0.91	0.89	0.8	2.4	4	0.07	0.30	0.91	1.00
3	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	1.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	3	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.15	2.35	2.8
6	4.5	8	0	0	8	8	0	0	0.8	2.4	4	0.11	0.47	1.32	1.78	0.8	2.4	4	0.07	0.28	1.32	1.53
7	3	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.3	0.9	1.5	0.03	0.04	0.11	0.08
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.267	1.72	2.07
10	3.25	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.03	0.108	0.25	0.23
11	5.25	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	0.66	2.45	3.13	0.9	2.7	4.5	0.08	0.39	2.45	3.00
12	5	10	0	0	10	10	0	0	1	3	5	0.14	0.69	3.54	4.86	1	3	5	0.08	0.417	3.54	4.17
13	1.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	4.75	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.277	4.25	4.61
17	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19	3.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
20	6.5	10	0	0	0	0	10	10	1	3	5	0.14	0.90	5.63	6.25	1	3	5	0.08	0.54	5.63	6.00
21	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
22	5.25	7	0	0	0	0	7	7	0.7	2.1	3.5	0.10	0.51	6.07	7.00	0.7	2.1	3.5	0.06	0.31	6.07	6.18
23	5.75	10	0	0	0	0	10	10	1	3	5	0.14	0.80	8.23	9.03	1	3	5	0.08	0.48	8.23	8.25
24	3.75	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.19	2.62	3.10
25	4.5	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.08	0.34	8.89	9.00
26	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
27	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
28	4.5	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.188	4.65	4.63
29	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	5.25	10	0	0	0	0	10	10	1	3	5	0.14	0.73	7.34	7.64	1	3	5	0.08	0.44	7.34	7.42
31	3.25	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Network 1102

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	7.25	10	0	0	10	10	0	0	1	3	5	0.13	0.95	1.52	2.50	1	3	5	0.08	0.57	1.52	1.48
3	3.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	7.25	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12	0.86	0.58	1.07	0.9	2.7	4.5	0.07	0.51	0.58	0.63
5	8	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12	0.95	2.05	3.32	0.9	2.7	4.5	0.07	0.56	2.05	1.97
6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7	4.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	8	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12	0.95	2.53	4.38	0.9	2.7	4.5	0.07	0.56	2.53	2.60
9	3.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	7.25	10	10	0	10	0	10	10	10	10	10	10	10	10	10	1	3	5	0.08	0.57	5.73	5.70
11	4.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
12	7	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.05	0.38	3.52	3.45
13	4.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
14	9	10	0	0	0	0	10	10	1	3	5	0.13	1.18	7.13	7.50	1	3	5	0.08	0.70	7.13	7.27
15	4.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	9.25	10	0	0	0	0	10	10	1	3	5	0.13	1.22	8.01	8.82	1	3	5	0.08	0.72	8.01	7.42
17	6.75	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.4	1.2	2	0.03	0.21	3.30	3.34
18	4.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19	5.25	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.06	0.33	3.70	3.50
20	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
21	7.5	10	0	0	0	0	10	10	1	3	5	0.13	0.99	6.32	6.18	1	3	5	0.08	0.59	6.32	6.48
22	6.5	9	9	0	9	9	9	0	9	9	9	9	9	9	9	0.9	2.7	4.5	0.07	0.46	3.63	3.38
23	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
24	9.5	9	0	0	0	0	9	9	0.9	2.7	4.5	0.12	1.13	8.32	9.00	0.9	2.7	4.5	0.07	0.67	8.32	8.16
25	6.75	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.26	5.00	5.00
26	2.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
27	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
28	7.5	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.05	0.41	6.75	6.73
29	4.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
31	6	2	2	0	2	2	2	0	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.09	0.60	0.61
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1105

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5.75	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.07	0.42	0.46	0.59
3	4.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
4	5.75	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.369	1.09	0.96
5	8.5	8	0	0	8	8	0	0	0.8	2.4	4	0.13	1.10	1.58	1.03	0.8	2.4	4	0.07	0.62	1.58	1.69
6	7.75	8	0	0	8	8	0	0	0.8	2.4	4	0.13	1	1.92	2.06	0.8	2.4	4	0.07	0.57	1.92	2.28
7	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
8	7.5	10	0	0	10	10	0	0	1	3	5	0.16	1.21	3.23	4.19	1	3	5	0.09	0.69	3.23	3.76
9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
10	3.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
11	4.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
12	7	5	0	0	5	5	0	0	0.5	1.5	2.5	0.08	0.56	2.11	2.5	0.5	1.5	2.5	0.05	0.321	2.11	2.2
13	6	2	2	0	2	2	2	0	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.11	0.79	0.79
14	9	8	0	0	0	0	8	8	0.8	2.4	4	0.13	1.16	3.96	5.03	0.8	2.4	4	0.07	0.66	3.96	4.33
15	7.25	6	0	0	0	0	6	6	0.6	1.8	3	0.1	0.7	3.16	4.35	0.6	1.8	3	0.06	0.399	3.16	3.58
16	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
17	5.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
18	7.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.466	6.34	5.91
19	4.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
20	4.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
21	8.75	10	0	0	0	0	10	10	1	3	5	0.16	1.41	9.95	10	1	3	5	0.09	0.803	9.95	10
22	6.5	10	#	0	10	0	10	10	10	10	10	10	10	10	10	1	3	5	0.09	0.60	8.44	7.80
23	6	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.06	0.33	4.63	3.91
24	5.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
25	8.5	7	0	0	0	0	7	7	0.7	2.1	3.5	0.11	0.96	6.60	5.87	0.7	2.1	3.5	0.06	0.55	6.60	6.36
26	5.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	6	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.4	1.2	2	0.04	0.22	3.17	2.75
28	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
29	4.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
30	5.75	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.3	0.9	1.5	0.03	0.16	1.31	1.40
31	4.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1112

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3	5.25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	4.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
5	5.75	10	10	0	10	10	10	0	10	10	10	10	10	10	10	1	3	5	0.09	0.52	1.22	0.91
6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7	4.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	5.75	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.04	0.21	1.59	1.05
9	3.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
10	6.5	9	9	0	9	9	9	0	9	9	9	9	9	9	9	0.9	2.7	4.5	0.08	0.532	4.99	4.5
11	9	9	0	0	9	9	0	0	0.9	2.7	4.5	0.14	1.29	3.35	1.29	0.9	2.7	4.5	0.08	0.74	3.35	2.05
12	7	5	0	0	5	5	0	0	0.5	1.5	2.5	0.08	0.56	2.5	2.06	0.5	1.5	2.5	0.05	0.318	2.5	2.09
13	6.25	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.34	1.83	0.87
14	3.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
15	7.75	8	0	0	8	8	0	0	0.8	2.4	4	0.13	0.98	3.56	2.16	0.8	2.4	4	0.07	0.564	3.56	2.69
16	6.75	4	0	0	4	4	0	0	0.4	1.2	2	0.06	0.43	1.88	1.33	0.4	1.2	2	0.04	0.245	1.88	1.49
17	4.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	8	10	0	0	0	0	10	10	1	3	5	0.16	1.27	7.62	5.71	1	3	5	0.09	0.73	7.62	7.09
20	6	2	2	0	2	0	2	2	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.11	1.55	1.45
21	9.5	10	0	0	0	0	10	10	1	3	5	0.16	1.51	9.33	8.89	1	3	5	0.09	0.864	9.33	9.36
22	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
23	5.5	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.30	3.73	3.33
24	7.75	7	0	0	0	0	7	7	0.7	2.1	3.5	0.11	0.86	6.87	7	0.7	2.1	3.5	0.06	0.49	6.87	7.00
25	6.75	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.43	4.74	4.33
26	6.25	3	3	0	3	0	3	3	3	3	3	3	3	3	3	0.3	0.9	1.5	0.03	0.17	2.38	2.26
27	7.5	10	0	0	0	0	10	10	1	3	5	0.16	1.19	8.72	7.3	1	3	5	0.09	0.682	8.72	8.45
28	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
29	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	5.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
31	5.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1119

RCP Input Files: Project Task Duration Times

			Optimistic		Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	5.75	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.05	0.26	0.57	0.82
5	8.25	8	0	0	8	8	0	0	0.8	2.4	4	0.12	0.97	0.38	0.94	0.8	2.4	4	0.07	0.60	0.38	0.58
6	4.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
7	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	7	9	9	0	9	9	9	0	9	9	9	9	9	9	9	0.9	2.7	4.5	0.08	0.57	3.93	4.09
9	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	8.25	9	0	0	9	9	0	0	0.9	2.7	4.5	0.13	1.09	1.83	2.25	0.9	2.7	4.5	0.08	0.68	1.83	2.21
11	6.25	10	10	0	10	0	10	10	10	10	10	10	10	10	10	1	3	5	0.09	0.57	4.97	5.45
12	7.25	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.5	1.5	2.5	0.05	0.33	0.39	0.59
13	8	6	0	0	6	6	6	0	0.6	1.8	3	0.09	0.71	1.44	2.03	0.6	1.8	3	0.05	0.44	1.44	1.80
14	4.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	3.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	5.25	1	1	0	1	1	1	0	1	1	1	1	1	1	1	0.1	0.3	0.5	0.01	0.05	0.38	0.37
17	8.25	7	0	0	7	7	0	0	0.7	2.1	3.5	0.10	0.85	2.64	3.09	0.7	2.1	3.5	0.06	0.53	2.64	2.55
18	4.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
19	5.25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
20	4.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
21	2.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
22	9.25	10	0	0	0	0	10	10	1	3	5	0.15	1.36	9.22	10	1	3	5	0.09	0.84	9.22	9.45
23	7	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.38	6.00	6.00
24	8.5	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	1.13	5.55	5.16	0.9	2.7	4.5	0.08	0.70	5.55	6.14
25	7.75	10	0	0	0	0	10	10	1	3	5	0.15	1.14	7.19	7.21	1	3	5	0.09	0.70	7.19	7.73
26	6.5	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.4	1.2	2	0.04	0.24	2.25	2.40
27	5.75	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
28	7	9	0	0	0	0	9	9	0.9	2.7	4.5	0.13	0.93	7.28	7.68	0.9	2.7	4.5	0.08	0.57	7.28	7.69
29	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	5.75	2	2	0	2	0	2	2	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.10	1.08	1.13
31	4.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1127

RCP Input Files: Project Task Duration Times

Activity Number	SN	P	Optimistic		Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
			OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	5.25	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
4	8	10	0	0	10	10	0	0	1	3	5	0.143	1.143	1.657	2.143	1	3	5	0.081	0.645	1.657	1.21
5	5.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6	4.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	5.75	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.03	0.19	1.42	1.42
8	7.5	5	0	0	5	5	0	0	0.5	1.5	2.5	0.071	0.536	0.314	0.357	0.5	1.5	2.5	0.04	0.30	0.31	0.20
9	7.75	9	0	0	0	0	9	9	0.9	2.7	4.5	0.129	0.996	5.349	5.529	0.9	2.7	4.5	0.073	0.563	5.349	5.52
10	5.75	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.056	0.325	3	2.88
11	6.75	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.33	2.78	2.76
12	7.5	10	10	0	10	0	10	10	10	10	10	10	10	10	10	1	3	5	0.081	0.605	5.429	5.4
13	5.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
14	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
16	8.5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.129	1.093	2.16	3.086	0.9	2.7	4.5	0.073	0.617	2.16	1.74
17	9	10	0	0	10	10	0	0	1	3	5	0.14	1.29	3.31	4.86	1	3	5	0.08	0.73	3.31	3.23
18	6.5	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.073	0.472	6.789	6.53
19	7.75	10	0	0	0	0	10	10	1	3	5	0.14	1.11	9.37	10.00	1	3	5	0.08	0.63	9.37	9.44
20	6.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
21	7.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.056	0.409	6.96	7
22	3.25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
23	5.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	9	9	0	0	0	0	9	9	0.9	2.7	4.5	0.129	1.157	7.509	6.686	0.9	2.7	4.5	0.07	0.65	7.51	7.19
25	8.5	8	0	0	0	0	8	8	0.8	2.4	4	0.11	0.97	7.04	6.86	0.8	2.4	4	0.06	0.55	7.04	6.90
26	7.25	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.5	1.5	2.5	0.04	0.292	3.371	3.27
27	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
28	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	3.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	4.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
31	7.5	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.048	0.363	1.646	1.45
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1200

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	0.10	0.30	0.50	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	4.5	9	9	0	9	9	9	0	9	9	9	9	9	9	9	0.90	2.70	4.50	0.07	0.31	1.14	1.31
4	5.25	10	0	0	10	10	0	0	1.00	3.00	5.00	0.1389	0.7292	0.7735	1.3889	1.00	3.00	5.00	0.08	0.40	0.77	0.76
5	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.80	2.40	4.00	0.06	0.24	1.55	1.65
7	3.5	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.70	2.10	3.50	0.05	0.19	2.05	1.82
8	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	5.25	9	0	0	9	9	0	0	0.90	2.70	4.50	0.125	0.6563	3.1326	2.375	0.90	2.70	4.50	0.07	0.36	3.13	2.95
12	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
13	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.80	2.40	4.00	0.06	0.24	3.80	3.73
14	5	10	0	0	10	10	0	0	1.00	3.00	5.00	0.1389	0.6944	4.3094	4.0278	1.00	3.00	5.00	0.08	0.38	4.31	4.05
15	6	10	0	0	10	10	0	0	1.00	3.00	5.00	0.14	0.83	5.30	5.42	1.00	3.00	5.00	0.08	0.46	5.30	5.42
16	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
17	6.25	9	0	0	0	0	9	9	0.90	2.70	4.50	0.125	0.7813	5.4199	6	0.90	2.70	4.50	0.07	0.43	5.42	5.50
18	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20	3.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
21	4	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.80	2.40	4.00	0.06	0.24	5.17	5.37
22	4	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.70	2.10	3.50	0.05	0.21	5.07	5.08
23	4.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.70	2.10	3.50	0.05	0.23	5.57	5.45
24	2.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
25	4.75	8	0	0	0	0	8	8	0.80	2.40	4.00	0.1111	0.5278	6.7182	6.2222	0.80	2.40	4.00	0.06	0.29	6.72	6.72
26	4.25	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.50	1.50	2.50	0.04	0.16	4.34	4.39
27	2.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	5	8	0	0	0	0	8	8	0.80	2.40	4.00	0.11	0.56	7.29	7.11	0.80	2.40	4.00	0.06	0.31	7.29	7.51
29	3.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
30	5	8	0	0	0	0	8	8	0.80	2.40	4.00	0.1111	0.5556	7.6906	8	0.80	2.40	4.00	0.06	0.31	7.69	8.00
31	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1201

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules																	
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	0.10	0.30	0.50	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5	10	0	0	10	10	0	0	1	3	5	0.15	0.76	1.31	1.52	1	3	5	0.10	0.49	1.31	1.36
3	1.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	4	8	0	0	8	8	0	0	0.8	2.4	4	0.12	0.48	1.77	2.18	0.8	2.4	4	0.08	0.31	1.77	2.10
6	2.75	4	4	0	4	4	4	0	4	4	4	4	4	4	4	0.4	1.2	2	0.04	0.11	0.25	0.16
7	2.5	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.3	0.9	1.5	0.03	0.07	0.50	0.55
8	2.25	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.3	0.9	1.5	0.03	0.07	0.72	0.87
9	1.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	1.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
11	2.25	2	2	0	2	2	2	0	2	2	2	2	2	2	2	0.2	0.6	1	0.02	0.04	0.29	0.31
12	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	3.5	7	0	0	7	7	0	0	0.7	2.1	3.5	0.11	0.37	2.70	3.18	0.7	2.1	3.5	0.07	0.24	2.70	2.85
14	3.25	5	0	0	5	5	0	0	0.5	1.5	2.5	0.08	0.25	1.48	1.74	0.5	1.5	2.5	0.05	0.16	1.48	1.70
15	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
17	5.5	10	0	0	0	0	10	10	1	3	5	0.15	0.83	5.17	6.06	1	3	5	0.10	0.53	5.17	5.05
18	1.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19	5.25	9	0	0	0	0	9	9	0.9	2.7	4.5	0.14	0.72	5.21	6.68	0.9	2.7	4.5	0.09	0.46	5.21	5.33
20	3.75	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.5	1.5	2.5	0.05	0.18	3.34	3.54
21	1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	3.5	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.06	0.20	4.26	4.60
23	3.75	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.07	0.25	4.44	4.62
24	3.5	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.07	0.24	5.31	5.84
25	6	8	0	0	0	0	8	8	0.8	2.4	4	0.12	0.73	6.57	6.91	0.8	2.4	4	0.08	0.47	6.57	7.30
26	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
28	3.25	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
29	1.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
30	5	9	0	0	0	0	9	9	0.9	2.7	4.5	0.14	0.68	9.00	9.00	0.9	2.7	4.5	0.09	0.44	9.00	9.00
31	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1212

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules																	
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	0.10	0.30	0.50	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5	10	0	0	10	10	0	0	1	3	5	0.14	0.68	1.06	1.35	1	3	5	0.0746269	0.373134	1.0615	1.3433
3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	4.75	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12	0.58	1.51	2.31	0.9	2.7	4.5	0.067	0.319	1.508	1.813
5	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.060	0.239	0.402	0.478
7	4.5	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.0597015	0.268657	1.6983	2.0896
8	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
9	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
10	5.25	10	0	0	10	10	0	0	1	3	5	0.14	0.71	4.30	3.92	1	3	5	0.075	0.392	4.302	4.478
11	6.25	10	0	0	10	10	0	0	1	3	5	0.14	0.84	4.86	5.27	1	3	5	0.0746269	0.466418	4.8603	5.2239
12	4.25	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.052	0.222	2.073	2.194
13	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
14	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.8	2.4	4	0.060	0.239	2.994	2.985
15	4.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.052	0.222	3.872	4.022
16	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
18	6.5	10	0	0	0	0	10	10	1	3	5	0.14	0.88	6.65	6.62	1	3	5	0.0746269	0.485075	6.648	7.1642
19	4.5	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.9	2.7	4.5	0.067	0.302	5.480	5.776
20	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	2.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
22	5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.8	2.4	4	0.0597015	0.298507	6.257	6.6866
23	5.25	8	0	0	0	0	8	8	0.8	2.4	4	0.11	0.57	5.90	6.16	0.8	2.4	4	0.0597015	0.313433	5.8994	6.209
24	1.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
25	5.25	9	0	0	0	0	9	9	0.9	2.7	4.5	0.12	0.64	7.84	8.03	0.9	2.7	4.5	0.0671642	0.352612	7.8436	8.1269
26	1.25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
27	3.75	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.5	1.5	2.5	0.037	0.140	4.777	4.701
28	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
29	2.25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
30	5.75	8	0	0	0	0	8	8	0.8	2.4	4	0.11	0.62	8.00	8.00	0.8	2.4	4	0.0597015	0.343284	8	8
31	3.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1222

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4.75	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12329	0.58562	1.11111	1.10959	0.9	2.7	4.5	0.07	0.34	1.11	1.15
3	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	3.5	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.20	0.48	0.39
5	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	3.25	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.16	1.00	1.06
7	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	4.5	7	0	0	7	7	0	0	0.7	2.1	3.5	0.09589	0.43151	2.07407	1.53425	0.7	2.1	3.5	0.06	0.25	2.07	1.96
9	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6.00
10	4	8	0	0	8	8	0	0	0.8	2.4	4	0.1096	0.4384	3.3086	3.6164	0.8	2.4	4	0.06	0.26	3.31	3.33
11	3.5	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.17	1.52	1.34
12	5	9	0	0	9	9	0	0	0.9	2.7	4.5	0.12	0.62	3.17	3.08	0.9	2.7	4.5	0.07	0.36	3.17	3.17
13	3.75	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.18	2.74	2.78
14	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	1.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
19	3.25	3	3	0	3	0	3	3	3	3	3	3	3	3	3	0.3	0.9	1.5	0.02	0.08	1.48	1.46
20	2.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
21	5.5	10	10	0	10	0	10	10	10	10	10	10	10	10	10	1	3	5	0.08	0.44	5.68	5.68
22	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
24	6.5	10	0	0	0	0	10	10	1	3	5	0.14	0.89	6.54	5.89	1	3	5	0.08	0.52	6.54	6.48
25	3.5	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.20	5.40	4.93
26	3	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
27	5.75	10	0	0	0	0	10	10	1	3	5	0.1370	0.7877	8.3333	7.2603	1	3	5	0.08	0.46	8.33	7.84
28	5.75	10	0	0	0	0	10	10	1	3	5	0.14	0.79	10.00	10.00	1	3	5	0.08	0.46	10.00	10.00
29	3.75	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.21	6.14	5.88
30	5.75	10	0	0	0	0	10	10	1	3	5	0.13699	0.78767	9.38272	8.63014	1	3	5	0.08	0.46	9.38	9.20
31	3.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1225

RCP Input Files: Project Task Duration Times

		Optimistic			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	4.25	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.80	2.40	4.00	0.07	0.28	0.55	0.53
6	5	9	0	0	9	9	0	0	0.90	2.70	4.50	0.13	0.63	1.12	1.14	0.90	2.70	4.50	0.08	0.38	1.12	1.28
7	4.75	8	0	0	8	8	0	0	0.80	2.40	4.00	0.11	0.54	1.44	1.92	0.80	2.40	4.00	0.07	0.32	1.44	1.67
8	4	8	8	0	8	8	8	0	8	8	8	8	8	8	8	0.80	2.40	4.00	0.07	0.27	2.24	2.20
9	2.75	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
10	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12	5.25	10	0	0	10	10	0	0	1.00	3.00	5.00	0.14	0.74	4.41	5.07	1.00	3.00	5.00	0.08	0.44	4.41	4.83
13	5.75	9	0	0	9	9	0	0	0.90	2.70	4.50	0.13	0.73	3.41	3.30	0.90	2.70	4.50	0.08	0.43	3.41	3.60
14	4.75	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.60	1.80	3.00	0.05	0.24	1.94	1.95
15	2.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4.00	4.00	4.00	4.00	4.00	4.00	4.00
16	6	10	0	0	0	0	10	10	1.00	3.00	5.00	0.14	0.85	5.71	6.48	1.00	3.00	5.00	0.08	0.50	5.71	6.25
17	4	7	7	0	7	7	7	7	7	7	7	7	7	7	7	0.70	2.10	3.50	0.06	0.23	3.57	3.79
18	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19	2.75	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	3.25	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.60	1.80	3.00	0.05	0.16	3.95	4.05
21	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3.00	3.00	3.00	3.00
22	3.25	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.50	1.50	2.50	0.04	0.14	3.57	3.58
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00
24	5	10	0	0	0	0	10	10	1.00	3.00	5.00	0.14	0.70	7.76	7.89	1.00	3.00	5.00	0.08	0.42	7.76	8.00
25	4	6	0	0	0	0	6	6	0.60	1.80	3.00	0.08	0.34	5.33	5.24	0.60	1.80	3.00	0.05	0.20	5.33	5.10
26	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	2.75	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
28	3	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.40	1.20	2.00	0.03	0.10	3.65	3.53
29	3	5	5	0	5	0	5	5	5	5	5	5	5	5	5	0.50	1.50	2.50	0.04	0.13	5.00	5.00
30	6.75	9	0	0	0	0	9	9	0.90	2.70	4.50	0.13	0.86	8.72	9.00	0.90	2.70	4.50	0.08	0.51	8.72	8.63
31	2.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1300

		RanGen Input --- Activity Durations																				
					Perfect Knowledge Schedules				Buffer Sizes - Low Level of Stochasticity							Buffer Sizes- High Level of Stochsticity						
Activity Number	Activity Duration	P	OL	OH	EL	EH	LL	LH	0.1	0.3	0.5	JG3	JG4	JG5	JG6	0.1	0.3	0.5	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.000	0.000	0.0	0.0
2	5	5	5	5	5	5	5	5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.000	5.000	5.0	5.0
3	7	7	7	7	7	7	7	7	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.000	7.000	7.0	7.0
4	5	5	5	0	5	5	5	0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	0.5	1.5	2.5	0.046	0.243	0.3	0.2
5	1	1	1	1	1	1	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.000	1.000	1.0	1.0
6	6	6	6	0	6	6	6	0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	0.6	1.8	3.0	0.056	0.361	0.9	0.6
7	9	9	0	0	9	9	0	0	0.9	2.7	4.5	0.1	1.1	2.4	2.3	0.9	2.7	4.5	0.083	0.771	2.4	2.8
8	3	3	3	0	3	3	3	0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.3	0.9	1.5	0.028	0.160	0.7	0.7
9	10	10	0	0	10	10	0	0	1.0	3.0	5.0	0.1	1.3	2.0	1.4	1.0	3.0	5.0	0.093	0.880	2.0	1.9
10	6	6	6	6	6	6	6	6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.000	6.000	6.0	6.0
11	10	10	0	0	10	10	0	0	1.0	3.0	5.0	0.1	1.2	3.3	4.0	1.0	3.0	5.0	0.093	0.833	3.3	4.0
12	8	8	8	8	8	8	8	8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.000	8.000	8.0	8.0
13	5	5	5	5	5	5	5	5	5.0	5.0	5.0	5.0	5.0	4.0	4.0	5.0	5.0	5.0	5.000	5.000	4.0	4.0
14	6	6	6	6	6	6	6	6	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.000	6.000	6.0	6.0
15	6	6	6	0	6	6	6	0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	0.6	1.8	3.0	0.056	0.347	3.1	2.7
16	1	1	1	1	1	1	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.000	1.000	1.0	1.0
17	6	6	0	0	0	0	6	6	0.6	1.8	3.0	0.1	0.6	3.7	3.6	0.6	1.8	3.0	0.056	0.403	3.7	3.6
18	9	9	0	0	9	9	0	0	0.9	2.7	4.5	0.1	1.1	5.1	4.7	0.9	2.7	4.5	0.083	0.729	5.1	4.8
19	3	3	3	0	3	0	3	3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.3	0.9	1.5	0.028	0.139	1.9	1.9
20	2	2	2	2	2	2	2	2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.000	2.000	2.0	2.0
21	8	8	8	8	8	8	8	8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.000	8.000	8.0	8.0
22	3	3	3	3	3	3	3	3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.000	3.000	3.0	3.0
23	2	2	2	0	2	0	2	2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.2	0.6	1.0	0.019	0.088	1.6	1.5
24	10	10	0	0	0	0	10	10	1.0	3.0	5.0	0.1	1.3	7.6	7.4	1.0	3.0	5.0	0.093	0.880	7.6	7.1
25	3	3	3	3	3	3	3	3	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.000	3.000	3.0	3.0
26	10	10	0	0	0	0	10	10	1.0	3.0	5.0	0.1	1.0	8.5	8.8	1.0	3.0	5.0	0.093	0.648	8.5	8.2
27	5	5	5	0	5	0	5	5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.5	1.5	2.5	0.005	0.278	4.6	4.4
28	9	9	0	0	0	0	9	9	0.9	2.7	4.5	0.1	0.9	8.7	9.0	0.9	2.7	4.5	0.083	0.583	8.7	8.6
29	5	5	5	0	5	0	5	5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.5	1.5	2.5	0.046	0.231	5.0	5.0
30	2	2	2	2	2	2	2	2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.000	2.000	2.0	2.0
31	4	4	4	4	4	4	4	4	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.000	4.000	4.0	4.0
32	0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1304

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	0.10	0.30	0.50	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
3	2.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	8.5	8	0	0	8	8	0	0	0.80	2.40	4.00	0.12	1.03	0.71	0.97	0.80	2.40	4.00	0.077	0.654	0.71	0.231
5	7.25	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.60	1.80	3.00	0.058	0.418	1.10	0.923
6	7.5	7	0	0	7	7	0	0	0.70	2.10	3.50	0.11	0.80	1.04	1.59	0.70	2.10	3.50	0.067	0.505	1.04	0.606
7	3.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	4.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	6.25	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.30	0.90	1.50	0.029	0.180	0.66	0.548
10	8.25	10	0	0	10	10	0	0	1.00	3.00	5.00	0.15	1.25	2.78	3.79	1.00	3.00	5.00	0.096	0.793	2.78	2.788
11	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
12	7.5	10	10	0	10	10	10	0	10	10	10	10	10	10	10	1.00	3.00	5.00	0.096	0.721	3.67	3.750
13	4.25	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
14	8.75	8	0	0	8	8	0	0	0.80	2.40	4.00	0.12	1.06	3.55	4.00	0.80	2.40	4.00	0.077	0.673	3.55	3.615
15	6	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.70	2.10	3.50	0.067	0.404	3.40	3.635
16	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
17	2.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
19	4.5	3	3	0	3	0	3	3	3	3	3	3	3	3	3	0.30	0.90	1.50	0.029	0.130	1.92	1.933
20	9.5	10	0	0	0	0	10	10	1.00	3.00	5.00	0.15	1.44	6.21	6.52	1.00	3.00	5.00	0.096	0.913	6.21	5.481
21	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	3.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
23	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	5	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.40	1.20	2.00	0.038	0.192	2.77	2.615
25	4.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
26	7.5	6	0	0	0	0	6	6	0.60	1.80	3.00	0.09	0.68	4.90	5.18	0.60	1.80	3.00	0.058	0.433	4.90	4.731
27	7.25	8	0	0	0	0	8	8	0.80	2.40	4.00	0.12	0.88	6.25	6.18	0.80	2.40	4.00	0.077	0.558	6.25	5.692
28	6.5	9	9	0	9	0	9	9	9	9	9	9	9	9	9	0.90	2.70	4.50	0.087	0.563	7.83	7.875
29	6	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.40	1.20	2.00	0.038	0.231	3.57	3.654
30	4.5	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
31	9.5	9	0	0	0	0	9	9	0.90	2.70	4.50	0.14	1.30	9.00	9.00	0.90	2.70	4.50	0.087	0.822	9.00	9.000
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Yellow	Early Schedule Low Level
Light blue	Early Schedule High Level
Purple	Late Schedule Low Level
Orange	Late Schedule High Level

Network 1308

RCP Input Files: Project Task Duration Times

					Perfect Knowledge Schedules																	
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	4.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	5.25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
5	3.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	6.75	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.70	2.10	3.50	0.06	0.39	1.34	0.75
7	3.5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	4.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
9	6.5	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.60	1.80	3.00	0.05	0.32	0.92	0.30
10	7.25	10	0	0	10	10	0	0	1.00	3.00	5.00	0.1449	1.0507	3.1073	2.4638	1.00	3.00	5.00	0.08	0.60	3.11	2.48
11	9.75	10	0	0	10	10	0	0	1.00	3.00	5.00	0.144928	1.413043	3.672316	3.913043	1.00	3.00	5.00	0.08	0.81	3.67	3.31
12	7	10	10	0	10	10	10	0	10	10	10	10	10	10	10	1.00	3.00	5.00	0.08	0.58	4.75	4.88
13	8.5	7	0	0	7	7	0	0	0.70	2.10	3.50	0.101449	0.862319	1.779661	0.710145	0.70	2.10	3.50	0.06	0.49	1.78	1.16
14	8.75	10	0	0	10	10	0	0	1.00	3.00	5.00	0.1449	1.2681	5.3672	5.3623	1.00	3.00	5.00	0.08	0.72	5.37	5.70
15	6.25	7	0	0	0	0	7	7	0.70	2.10	3.50	0.10	0.63	4.03	4.46	0.70	2.10	3.50	0.06	0.36	4.03	4.40
16	6.5	9	9	0	9	9	9	0	9	9	9	9	9	9	9	0.90	2.70	4.50	0.07	0.48	3.76	3.64
17	6.25	6	0	0	0	0	6	6	0.60	1.80	3.00	0.086957	0.543478	3.728814	4.347826	0.60	1.80	3.00	0.05	0.31	3.73	4.07
18	5.75	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.70	2.10	3.50	0.06	0.33	4.63	5.15
19	5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	5.75	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.40	1.20	2.00	0.03	0.19	2.73	3.07
21	9.5	10	0	0	0	0	10	10	1.00	3.00	5.00	0.144928	1.376812	7.40113	8.695652	1.00	3.00	5.00	0.08	0.79	7.40	8.51
22	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	5.5	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.60	1.80	3.00	0.05	0.27	4.64	5.40
25	5.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
26	4.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	3.5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
28	9.5	9	0	0	0	0	9	9	0.90	2.70	4.50	0.13	1.24	8.24	9.00	0.90	2.70	4.50	0.07	0.71	8.24	8.78
29	3.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
30	4.75	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
31	5.75	3	3	0	3	0	3	3	3	3	3	3	3	3	3	0.30	0.90	1.50	0.02	0.14	2.80	3.00
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(yellow)	Early Schedule Low Level
(light blue)	Early Schedule High Level
(purple)	Late Schedule Low Level
(orange)	Late Schedule High Level

Network 1314

RCP Input Files: Project Task Duration Times

		Perfect Knowledge Schedules																				
		.rcp file Duration Input Values							Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	0.10	0.30	0.50	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4	6.25	5	5	0	5	5	5	0	5	5	5	5	5	5	5	0.50	1.50	2.50	0.05	0.32	0.46	0.26
5	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	4.25	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.30	0.90	1.50	0.03	0.13	0.38	0.24
7	7	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.60	1.80	3.00	0.06	0.43	1.02	0.86
8	3.25	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
9	7.5	6	0	0	6	6	0	0	0.60	1.80	3.00	0.10	0.74	1.87	1.57	0.60	1.80	3.00	0.06	0.46	1.87	1.84
10	7.75	7	0	0	7	7	0	0	0.70	2.10	3.50	0.1148	0.8893	2.5319	2.6393	0.70	2.10	3.50	0.07	0.55	2.53	2.64
11	9.5	10	0	0	10	10	0	0	1.00	3.00	5.00	0.16393	1.55738	2.41135	1.63934	1.00	3.00	5.00	0.10	0.97	2.41	2.45
12	9.25	9	0	0	9	9	0	0	0.90	2.70	4.50	0.15	1.36	3.83	4.72	0.90	2.70	4.50	0.09	0.85	3.83	4.22
13	5.5	3	3	0	3	3	3	0	3	3	3	3	3	3	3	0.30	0.90	1.50	0.03	0.17	1.34	1.50
14	3.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	4.25	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
17	4.75	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
18	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
19	9.25	10	0	0	0	0	10	10	1.00	3.00	5.00	0.16	1.52	6.60	6.89	1.00	3.00	5.00	0.10	0.94	6.60	6.02
20	5.5	2	2	0	2	0	2	2	2	2	2	2	2	2	2	0.20	0.60	1.00	0.02	0.11	1.35	1.24
21	4.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	5.5	8	8	0	8	0	8	8	8	8	8	8	8	8	8	0.80	2.40	4.00	0.08	0.45	6.18	6.12
23	5.5	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.60	1.80	3.00	0.06	0.34	4.30	4.10
24	7.5	10	0	0	0	0	10	10	1.00	3.00	5.00	0.16	1.23	8.79	8.52	1.00	3.00	5.00	0.10	0.77	8.79	8.67
25	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	4.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	4.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
28	7	5	0	0	0	0	5	5	0.50	1.50	2.50	0.08	0.57	4.86	5.00	0.50	1.50	2.50	0.05	0.36	4.86	4.80
29	5.5	4	4	0	4	0	4	4	4	4	4	4	4	4	4	0.40	1.20	2.00	0.04	0.22	4.00	4.00
30	6	4	0	0	0	0	4	4	0.40	1.20	2.00	0.06557	0.39344	3.74468	3.67213	0.40	1.20	2.00	0.04	0.24	3.74	3.63
31	4.5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Early Schedule Low Level
Early Schedule High Level
Late Schedule Low Level
Late Schedule High Level

Network 1325

RCP Input Files: Project Task Duration Times

		.rcp file Duration Input Values			Perfect Knowledge Schedules				Buffer Sizes Low Level							Buffer Sizes High Level						
Activity Number	SN	P	OL	OH	EL	EH	LL	LH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.25	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	5	10	10	0	10	10	10	0	10	10	10	10	10	10	10	1	3	5	0.08	0.40	1.20	1.28
4	3.75	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	5.75	6	6	0	6	6	6	0	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.28	0.38	0.29
6	6.5	8	0	0	8	8	0	0	0.80	2.40	4.00	0.1176	0.7647	1.3257	0.9412	0.8	2.4	4	0.06	0.42	1.33	1.54
7	3.75	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	8.5	9	0	0	9	9	0	0	0.90	2.70	4.50	0.13235	1.125	2.21143	2.25	0.9	2.7	4.5	0.07	0.61	2.21	2.38
9	8	8	0	0	8	8	0	0	0.80	2.40	4.00	0.12	0.94	2.65	2.94	0.8	2.4	4	0.06	0.51	2.65	3.07
10	6.5	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.36	2.00	2.24
11	8.5	8	0	0	8	8	0	0	0.80	2.40	4.00	0.11765	1	3.01714	3.8823529	0.8	2.4	4	0.06	0.54	3.02	3.58
12	5.25	7	7	0	7	7	7	0	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.29	3.04	3.53
13	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
14	4.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
15	4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
16	3.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	8.25	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.46	3.80	3.92
18	5.25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
19	2.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	8	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.45	4.08	4.31
21	6.5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
22	7	7	7	0	7	0	7	7	7	7	7	7	7	7	7	0.7	2.1	3.5	0.06	0.39	4.80	4.70
23	4.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
24	6.25	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
25	9	8	0	0	0	0	8	8	0.80	2.40	4.00	0.11765	1.058824	6.26286	4.8235294	0.8	2.4	4	0.06	0.58	6.26	6.27
26	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
27	8	6	6	0	6	0	6	6	6	6	6	6	6	6	6	0.6	1.8	3	0.05	0.38	4.42	4.32
28	9	10	0	0	0	0	10	10	1.00	3.00	5.00	0.15	1.32	8.63	7.50	1	3	5	0.08	0.72	8.63	8.64
29	8.5	7	0	0	0	0	7	7	0.70	2.10	3.50	0.10	0.88	6.60	5.97	0.7	2.1	3.5	0.06	0.48	6.60	6.44
30	9.25	10	0	0	0	0	10	10	1.00	3.00	5.00	0.14706	1.360294	10	10	1	3	5	0.08	0.74	10.00	10.00
31	6.75	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX H
DH-ALGORITHM OUTPUT VALUE SUMMARY CHARTS

Network 1004

N = 30

Resource Types = 2

Max Units of Available of Each Resource Type = 1(

Low Network Parameters

Low Resource Paramters

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	0	6	6	6	0	6	6	0	6	6	6	6	6	6	6	1	2	3	1	1	1	1
3	6	0	6	0	6	0	6	0	0	1	2	3	1	1	1	1	1	2	3	1	1	1	1
4	9	6	15	0	15	0	15	0	0	2	5	8	2	2	4	6	2	5	8	2	2	4	4
5	10	0	10	0	10	0	10	0	0	1	3	5	1	1	3	4	1	3	5	1	1	3	3
6	5	15	20	11	20	0	20	11	0	11	11	13	11	11	11	11	3	7	11	3	3	6	6
7	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	1	6	7	7	7	1	7	7	1	7	7	7	7	7	7	7	2	3	4	2	2	2	2
9	9	0	9	0	9	0	9	0	0	1	3	5	1	1	2	2	1	3	5	1	1	2	2
10	2	6	8	8	8	2	8	8	2	8	8	8	8	8	8	8	3	4	5	3	3	3	3
11	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	7	11	15	7	7	10	10
12	3	20	23	14	23	7	23	14	7	14	14	16	14	14	14	14	7	10	14	7	7	9	9
13	7	20	27	18	20	11	20	11	4	12	14	17	12	12	15	16	5	10	15	5	5	10	10
14	2	15	17	8	17	2	17	8	2	8	8	10	8	8	8	8	4	7	10	4	4	6	6
15	4	24	28	19	28	8	28	19	8	19	19	21	19	19	19	19	11	15	19	11	11	14	14
16	8	28	36	27	28	16	28	19	8	20	22	25	20	20	26	26	12	18	23	12	12	21	21
17	7	24	31	22	31	11	31	22	11	22	22	24	22	22	22	22	14	18	22	14	14	17	17
18	1	27	28	19	21	12	21	12	5	13	15	18	13	13	16	17	6	11	16	6	6	11	11
19	8	20	28	19	28	12	20	19	4	19	19	21	19	19	19	19	5	10	15	5	5	11	11
20	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	5	9	13	5	5	8	8
21	10	20	30	21	20	14	20	11	4	12	14	18	12	12	18	19	5	10	16	5	5	13	13
22	4	20	24	15	24	4	24	15	4	15	15	17	15	15	15	15	7	11	15	7	7	10	10
23	9	30	39	30	28	23	28	19	8	21	25	30	21	21	34	28	12	18	24	12	12	24	24
24	2	36	38	29	30	18	30	21	10	22	24	27	22	22	28	28	14	20	25	14	14	23	23
25	1	28	29	20	29	13	24	20	8	20	20	22	20	20	20	20	8	11	16	8	8	12	12
26	8	36	44	35	39	24	31	30	11	30	30	32	30	30	30	34	15	21	27	15	15	29	29
27	8	32	40	31	32	24	24	23	4	23	23	25	23	23	23	31	8	14	19	8	8	18	18
28	9	23	32	23	32	20	23	23	7	23	23	25	23	23	23	23	8	13	19	8	8	16	16
29	2	27	29	20	25	13	25	16	9	16	16	19	16	16	17	18	9	12	17	9	9	12	12
30	1	23	24	15	24	8	24	15	8	15	15	17	15	15	15	15	8	11	15	8	8	10	10
31	6	15	21	14	21	4	21	14	4	14	14	14	14	14	14	14	5	7	11	5	5	7	7
32	0	44	44	35	39	24	31	30	11	30	30	32	30	30	34	34	15	21	27	15	15	29	29

Network 1010
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	8	0	8	8	8	0	8	8	0	8	8	8	8	8	8	8	1	3	4	1	1	2	2
3	7	8	15	15	15	0	15	15	0	15	15	15	15	15	15	15	2	6	8	2	2	5	4
4	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	8	0	8	0	8	0	8	0	0	1	3	4	1	1	2	1	1	3	4	1	1	2	1
6	3	15	18	18	18	4	18	18	4	18	18	18	18	18	18	18	5	9	11	5	5	8	7
7	10	0	10	0	10	0	10	0	0	1	3	5	1	1	3	3	1	3	5	1	1	3	3
8	6	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
9	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	1	10	11	1	11	1	11	1	1	2	4	6	2	2	4	4	2	4	6	2	2	4	4
11	8	18	26	18	26	4	26	18	4	19	21	22	19	19	22	22	6	12	15	6	6	12	11
12	8	18	26	26	26	4	26	26	4	26	26	26	26	26	26	26	6	12	15	6	6	13	12
13	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	6	18	24	24	24	6	24	24	6	24	24	24	24	24	24	24	7	11	14	7	7	11	10
15	8	15	23	15	23	2	23	15	2	16	18	19	16	16	19	18	3	9	12	3	3	9	7
16	2	26	28	20	28	8	28	20	8	21	23	24	21	21	24	24	8	14	17	8	8	14	13
17	2	26	28	20	28	12	26	20	6	21	23	24	21	21	24	24	7	13	16	7	7	14	13
18	7	24	31	27	30	9	15	22	2	22	22	26	22	22	26	22	3	9	16	3	3	15	10
19	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
20	6	26	32	32	32	10	26	32	4	32	32	32	32	32	32	32	7	14	18	7	7	18	17
21	8	32	40	40	40	18	26	40	6	40	40	40	40	40	40	40	8	17	22	8	8	26	25
22	1	40	41	41	41	19	29	41	9	41	41	41	41	41	41	41	9	18	23	9	9	27	26
23	1	26	27	27	27	7	27	27	7	27	27	27	27	27	27	27	8	13	16	8	8	14	13
24	1	32	33	33	31	14	29	23	9	23	24	27	23	23	33	25	9	15	19	9	9	16	18
25	7	33	40	35	28	19	26	26	6	27	29	33	27	27	38	37	8	16	23	8	8	25	24
26	4	28	32	30	32	12	32	30	12	30	30	30	30	30	30	30	12	18	21	12	12	18	17
27	1	26	27	27	27	7	27	27	7	27	27	27	27	27	27	27	7	13	16	7	7	14	13
28	1	26	27	25	25	13	25	25	7	25	25	25	25	25	25	25	8	12	16	8	8	13	11
29	8	28	36	34	26	12	26	26	4	27	29	31	27	27	34	33	8	15	20	8	8	24	21
30	10	23	33	28	18	16	18	18	6	22	25	29	22	22	31	30	7	12	19	7	7	18	17
31	10	18	28	28	18	16	18	18	6	19	21	23	19	19	25	25	7	12	16	7	7	15	14
32	0	41	41	41	41	19	32	41	12	41	41	41	41	41	41	41	12	18	23	12	12	27	26

Network 1015
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				rfect Knowledge Schedu				Optimistic Schedules		Buffered Schedules Low Level of Stochasticity							Buffered Schedules High Level of Stochasticity						
				Low Level		High Level																	
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	7	0	7	7	7	0	7	7	0	7	7	7	7	7	7	7	1	3	4	1	1	1	1
3	9	0	9	0	9	0	9	0	0	1	3	5	1	1	3	3	1	3	5	1	1	3	3
4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	5	0	5	5	5	0	5	5	0	5	5	5	5	5	5	5	1	2	3	1	1	1	1
7	8	0	8	0	8	0	8	0	0	1	3	4	1	1	2	1	1	3	4	1	1	2	2
8	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	2	8	10	7	10	2	10	7	2	7	7	7	7	7	7	7	3	5	6	3	3	4	4
11	5	9	14	5	14	5	14	5	5	6	8	10	6	6	8	8	6	8	10	6	6	8	8
12	9	3	12	3	12	3	12	3	3	4	6	8	4	4	6	7	4	6	8	4	4	6	6
13	6	12	18	13	18	4	18	13	4	13	13	14	13	13	13	13	5	8	11	5	5	9	9
14	1	9	10	8	10	4	10	8	4	8	8	8	8	8	8	8	4	4	6	4	4	4	4
15	4	18	22	17	22	8	22	17	8	17	17	18	17	17	17	17	9	12	15	9	9	13	13
16	7	14	21	14	14	12	14	7	5	9	11	14	9	9	12	13	7	11	14	7	7	12	12
17	10	4	14	4	14	4	14	4	4	5	7	9	5	5	8	10	5	7	9	5	5	8	8
18	7	22	29	24	22	15	22	17	8	18	20	22	18	18	22	23	12	15	19	12	12	19	19
19	9	22	31	26	22	17	22	17	8	18	20	23	18	18	26	25	10	15	20	10	10	22	22
20	8	14	22	16	22	13	14	15	5	15	16	18	15	15	16	16	7	11	14	7	7	13	13
21	8	14	22	13	22	13	14	13	5	14	16	18	14	14	16	16	7	11	14	7	7	13	14
22	8	31	39	34	22	25	22	17	8	21	23	27	21	21	34	33	13	19	24	13	13	30	30
23	6	22	28	23	28	19	28	23	14	23	23	24	23	23	23	23	15	18	21	15	15	19	20
24	6	21	27	20	24	18	24	19	11	19	19	20	19	19	19	19	13	17	20	13	13	18	18
25	8	22	30	25	30	16	22	25	8	25	25	26	25	25	25	25	10	15	19	10	10	20	20
26	3	22	25	20	25	15	25	20	11	20	20	21	20	20	20	20	12	16	18	12	12	16	16
27	5	22	27	21	27	18	19	20	10	20	21	23	20	20	21	21	12	16	19	12	12	18	18
28	7	18	25	20	25	19	18	20	5	20	20	26	20	20	25	20	8	16	18	8	8	19	18
29	6	25	31	26	20	25	20	14	10	15	17	19	15	15	18	26	11	13	15	11	11	14	24
30	6	9	15	20	15	4	15	13	4	13	13	13	13	13	13	13	5	6	8	5	5	7	7
31	7	12	19	14	19	11	19	14	11	14	14	15	14	14	14	14	11	13	15	11	11	13	13
32	0	39	39	34	30	25	28	25	14	25	25	27	25	25	34	33	15	19	24	15	15	30	30

Network 1020
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules Low Level of Stochasticity							Buffered Schedules High Level of Stochasticity						
				Low Level		High Level																	
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	7	0	7	7	7	0	7	7	0	7	7	7	7	7	7	7	1	3	4	1	1	1	1
3	2	7	9	9	9	2	9	9	2	9	9	9	9	9	9	9	3	5	6	3	3	3	3
4	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	8	0	8	0	8	0	8	0	0	1	3	4	1	1	2	1	1	3	4	1	1	2	2
6	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
7	5	0	5	5	5	0	5	5	0	5	5	5	5	5	5	5	1	2	3	1	1	1	1
8	8	9	17	9	17	5	17	9	5	10	12	13	10	10	13	13	6	8	10	6	6	9	9
9	1	9	10	16	10	3	10	10	3	10	11	12	10	10	10	10	4	7	9	4	4	4	4
10	7	7	14	7	14	0	14	7	0	8	10	11	8	8	9	9	2	6	8	2	2	3	3
11	7	8	15	7	15	0	15	7	0	8	10	11	8	8	9	8	2	6	8	2	2	5	5
12	2	7	9	9	9	2	9	9	2	9	9	9	9	9	9	9	3	5	6	3	3	3	3
13	1	10	11	17	11	6	11	11	6	11	12	13	11	11	11	11	6	8	10	6	6	6	6
14	4	17	21	20	21	10	21	13	9	14	16	17	14	14	17	17	10	12	14	10	10	13	13
15	10	9	19	19	9	15	9	9	5	10	12	14	10	10	14	15	6	8	11	6	6	10	11
16	7	9	16	16	16	5	16	16	5	16	16	16	16	16	16	16	6	8	10	6	6	8	8
17	4	10	14	13	14	6	14	13	6	13	13	13	13	13	13	13	7	9	10	7	7	7	7
18	6	17	23	15	23	11	17	19	5	18	18	19	18	18	19	19	7	10	13	7	7	13	13
19	9	7	16	7	16	2	16	7	2	8	10	12	8	8	10	11	3	6	9	3	3	5	5
20	6	27	33	26	27	21	27	22	15	22	22	23	22	22	23	23	16	18	20	16	16	22	23
21	10	23	33	26	23	21	17	19	5	19	21	24	19	19	27	28	8	13	20	8	8	21	22
22	7	23	30	23	22	18	15	17	3	21	23	23	21	21	23	23	5	13	17	5	5	22	23
23	4	24	28	23	26	16	21	21	9	22	22	23	22	22	24	23	10	12	19	10	10	18	18
24	6	21	27	25	23	16	23	16	11	17	18	19	17	18	19	19	12	14	21	12	12	22	23
25	6	33	39	32	33	27	33	28	21	28	29	30	28	28	33	35	22	24	26	22	22	28	29
26	4	33	37	30	31	25	31	26	19	26	26	32	26	26	34	35	20	22	25	20	20	26	27
27	7	33	40	33	34	28	27	29	15	29	30	31	29	29	34	35	17	21	24	17	17	29	30
28	1	23	24	24	24	12	18	11	6	11	20	23	11	11	20	20	9	13	15	9	9	14	14
29	9	27	36	28	15	24	15	10	5	12	19	22	12	17	26	29	6	13	20	6	6	22	22
30	9	14	23	28	23	24	14	18	5	18	19	20	18	18	18	18	6	9	13	6	6	10	11
31	10	17	27	19	17	15	17	9	5	11	29	28	11	12	30	31	8	16	15	8	8	16	17
32	0	40	40	33	34	28	33	28	21	29	30	32	29	29	34	35	22	24	26	22	22	29	30

Network 1028
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules						Buffered Schedules							Buffered Schedules						
				Low Level		High Level		Optimistic Schedules		Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	8	0	8	0	8	0	8	0	0	1	3	4	1	1	1	1	1	3	4	1	1	1	1
3	2	8	10	2	10	2	10	2	2	3	5	6	3	3	3	3	3	5	6	3	3	3	3
4	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	6	10	16	8	16	2	16	8	2	9	11	12	9	9	9	9	4	7	9	4	4	6	6
6	8	0	8	0	8	0	8	0	0	1	3	4	1	1	2	2	1	3	4	1	1	2	2
7	3	0	3	3	3	0	3	3	0	3	3	3	3	3	3	3	1	1	2	1	1	1	1
8	1	16	17	9	17	3	17	9	3	10	12	13	10	10	10	10	5	8	10	5	5	7	7
9	8	0	8	8	8	0	8	8	0	8	8	8	8	8	8	8	1	3	4	1	1	2	3
10	4	0	4	4	4	0	4	4	0	4	4	4	4	4	4	4	1	2	2	1	1	1	1
11	9	3	12	3	12	3	12	3	3	4	6	8	4	4	6	7	4	6	8	4	4	6	6
12	10	8	18	0	18	0	18	0	0	2	6	9	2	2	5	6	2	6	9	2	2	5	6
13	3	17	20	12	20	6	20	12	6	13	15	16	13	13	13	13	8	11	13	8	8	10	10
14	1	8	9	1	9	1	9	1	1	2	4	5	2	2	2	2	2	4	5	2	2	2	2
15	2	17	19	11	19	5	19	11	5	12	14	15	12	12	12	12	7	10	12	7	7	9	9
16	7	19	26	18	26	12	19	18	5	19	21	22	19	19	19	19	8	13	16	8	8	18	18
17	3	21	24	16	23	10	20	15	6	17	19	24	17	17	17	17	8	15	18	8	8	17	19
18	3	21	24	19	20	13	20	12	6	13	19	21	13	13	20	20	8	11	15	8	8	14	16
19	4	17	21	13	21	7	21	13	7	14	16	17	14	14	14	14	9	12	14	9	9	11	11
20	10	18	28	19	18	13	18	9	3	15	18	18	15	15	16	17	10	11	15	10	10	13	13
21	4	20	24	16	24	10	24	16	10	17	19	20	17	17	17	17	12	15	17	12	12	14	14
22	7	26	33	25	20	19	20	12	6	16	21	22	16	16	23	24	10	15	19	10	10	17	18
23	10	24	34	29	18	23	18	9	3	14	15	22	14	14	23	24	9	14	19	9	9	22	19
24	6	16	22	14	22	9	16	14	3	15	17	18	15	15	15	15	5	13	12	5	5	9	10
25	9	33	42	34	35	28	24	27	10	28	30	31	28	28	32	33	13	18	24	13	13	27	27
26	2	34	36	31	28	25	22	20	8	21	23	26	21	21	25	26	11	17	21	11	11	24	21
27	4	24	28	23	24	17	24	16	10	18	23	25	18	18	24	24	12	17	19	12	12	18	20
28	5	33	38	30	28	24	20	20	6	22	26	29	22	22	28	29	11	17	22	11	11	22	24
29	1	18	19	10	19	4	19	10	4	11	13	14	11	11	11	11	6	9	11	6	6	8	8
30	10	21	31	23	18	17	18	8	3	10	14	22	10	10	22	22	5	10	14	5	5	14	18
31	5	28	33	23	21	17	21	13	8	14	26	27	14	14	24	24	9	18	21	9	9	22	23
32	0	42	42	34	35	28	24	27	10	28	30	31	28	28	32	33	13	18	24	13	13	27	27

Network 1102
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	11	21	0	21	0	21	0	0	4	8	12	4	4	5	7	4	8	12	4	4	5	5
3	2	0	2	3	2	3	2	2	7	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	9	2	11	0	11	0	11	0	0	3	5	7	3	3	3	4	3	5	7	3	3	3	3
5	9	21	30	3	30	3	30	2	7	6	12	17	6	6	11	13	9	13	17	9	9	11	10
6	5	11	16	8	16	8	16	8	5	11	17	12	11	11	8	9	8	10	12	8	8	8	8
7	4	16	20	14	20	22	20	12	11	19	29	29	19	20	21	25	15	21	28	15	15	20	19
8	9	30	39	8	56	8	52	8	7	12	20	22	12	12	14	18	10	16	22	10	10	14	13
9	1	39	40	1	31	1	31	3	15	5	9	23	5	5	15	19	11	17	23	11	11	15	14
10	10	63	73	40	47	35	30	13	7	32	42	50	32	33	45	49	21	33	42	21	21	39	38
11	3	42	45	27	34	25	34	18	14	22	32	37	22	23	32	36	18	24	31	18	18	25	24
12	7	56	63	54	63	3	59	41	15	39	51	58	39	40	55	59	22	30	37	22	22	33	32
13	6	42	48	30	37	24	40	31	13	21	31	40	21	22	35	39	17	23	30	17	17	28	27
14	10	75	85	24	56	18	52	8	15	13	25	34	13	16	29	33	20	38	49	20	20	50	49
15	2	54	56	56	65	37	61	43	20	41	53	60	41	42	57	61	24	27	33	24	24	22	21
16	10	85	95	69	65	47	61	43	20	45	59	68	45	47	69	73	29	52	54	29	29	59	57
17	4	95	99	73	72	54	59	50	15	49	63	72	49	51	73	77	28	49	59	28	28	63	61
18	3	99	102	59	68	50	64	46	18	44	56	63	44	45	60	64	27	47	57	27	27	66	64
19	8	54	62	55	64	25	60	42	14	40	52	59	40	41	56	60	22	28	35	22	22	33	32
20	2	63	65	91	83	63	69	52	22	59	73	82	59	61	83	87	34	32	39	34	34	35	34
21	10	65	75	46	34	35	34	18	14	23	35	51	23	24	48	52	32	42	64	32	32	42	41
22	9	45	54	36	43	25	43	34	14	32	44	46	32	33	41	45	21	35	44	21	21	29	28
23	5	102	107	78	77	59	69	55	25	54	68	77	54	56	78	82	34	57	64	34	34	71	69
24	9	102	111	89	64	72	60	42	15	60	76	87	60	63	92	96	35	55	72	35	35	75	73
25	5	119	124	96	89	77	69	57	22	65	81	92	65	68	97	101	36	44	67	36	36	88	86
26	2	73	75	91	83	63	69	52	22	59	73	82	59	61	83	87	33	41	61	33	33	41	40
27	5	85	90	45	61	40	57	23	20	37	47	55	37	38	50	54	26	43	54	26	26	55	54
28	7	111	118	80	79	61	52	25	15	56	70	79	56	58	80	84	31	58	76	31	31	82	80
29	1	118	119	47	84	78	65	58	23	57	71	80	57	59	81	85	30	39	77	30	30	83	81
30	2	73	75	42	58	37	54	15	17	34	44	52	34	35	47	51	23	35	44	23	23	41	40
31	2	40	42	10	81	8	67	15	7	15	22	25	15	14	17	21	19	25	24	19	19	16	15
32	0	124	124	96	89	78	69	58	25	65	81	92	65	68	97	101	36	58	77	36	36	88	86

Network 1105

N = 30

Resource Types = 2

Max Units of Available of Each Resource Type = 10

Low Network Parameters

Low Resource Paramters

DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules						Buffered Schedules							Buffered Schedules						
				Low Level		High Level		Optimistic Schedules		Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	8	0	8	8	8	0	8	8	0	12	8	8	12	9	8	8	9	8	4	9	9	1	1
3	7	37	44	22	44	13	44	22	13	19	28	33	19	26	26	30	7	15	18	7	7	16	11
4	7	8	15	15	15	0	15	15	0	26	15	15	26	19	15	15	10	18	11	10	10	9	4
5	8	15	23	0	23	0	23	0	0	1	18	19	1	12	17	17	11	21	28	11	11	5	19
6	8	23	31	0	31	0	31	0	0	2	21	23	2	1	19	20	12	24	32	12	12	7	22
7	3	0	3	3	3	3	3	3	3	7	3	3	7	4	3	3	3	3	3	3	3	3	3
8	10	31	41	8	41	0	41	8	0	13	29	36	13	21	28	33	15	29	21	15	15	19	15
9	5	41	46	20	46	11	46	20	11	18	26	31	18	26	24	28	8	13	16	8	8	15	11
10	3	8	11	11	11	6	11	11	6	21	11	11	21	15	11	11	18	16	10	18	18	10	6
11	9	3	12	12	12	12	12	12	12	16	12	12	16	13	12	12	12	12	12	12	12	12	12
12	5	48	53	15	51	0	51	15	0	27	36	26	27	27	35	23	21	26	35	21	21	25	26
13	2	46	48	24	56	13	53	33	13	38	43	44	38	40	37	38	22	37	36	22	22	26	23
14	8	59	67	38	0	24	0	0	0	3	46	54	3	38	47	50	13	40	45	13	13	35	40
15	6	67	73	44	0	30	0	0	0	4	41	47	4	10	51	55	14	5	7	14	14	39	35
16	3	56	59	30	54	16	56	31	16	36	39	42	36	36	43	44	25	36	41	25	25	31	31
17	9	73	82	53	65	39	62	31	22	36	55	63	36	36	61	65	31	49	54	31	31	49	50
18	7	105	112	83	76	69	56	54	16	65	84	93	65	67	91	95	40	62	71	40	40	77	74
19	9	73	82	53	53	39	53	31	22	35	50	56	35	35	60	64	24	38	41	24	24	48	44
20	6	31	37	50	37	6	37	28	6	33	34	39	33	33	32	36	20	32	24	20	20	22	17
21	10	119	129	99	76	86	56	54	16	72	90	102	72	75	108	111	42	68	80	42	42	94	91
22	10	90	100	71	94	57	62	47	22	53	72	81	53	55	79	83	34	54	62	34	34	65	63
23	6	80	86	89	62	43	56	65	16	71	59	67	71	73	65	69	41	42	48	41	41	52	52
24	5	100	105	76	84	62	71	59	29	58	77	86	58	60	84	88	39	59	67	39	39	70	68
25	7	112	119	106	56	76	53	33	13	40	87	97	40	42	98	101	44	65	75	44	44	84	81
26	1	129	130	107	95	87	72	34	24	39	91	103	39	41	52	56	45	69	81	45	45	40	41
27	4	86	90	61	99	47	56	69	16	76	95	71	76	79	69	73	43	51	57	43	43	56	55
28	7	73	80	57	69	37	63	76	23	83	53	61	83	86	59	63	32	49	55	32	32	47	48
29	9	67	76	47	65	33	62	42	22	47	55	63	47	49	56	59	31	49	54	31	31	44	49
30	3	53	56	27	79	13	66	37	13	43	62	50	43	45	40	41	33	33	38	33	33	28	28
31	7	73	80	51	69	37	63	44	23	50	53	61	50	52	59	63	32	49	55	32	32	47	48
32	0	130	130	107	99	87	72	76	29	83	95	103	83	86	108	111	45	69	81	45	45	94	91

Network 1112
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	6	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
3	6	6	12	12	12	12	39	12	17	12	12	12	12	12	12	12	20	12	12	20	20	12	12
4	9	6	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
5	10	0	10	10	10	0	10	10	0	10	10	10	10	10	10	10	1	3	5	1	1	2	1
6	5	12	17	17	17	17	11	26	11	26	26	26	26	26	17	28	11	17	19	11	11	17	17
7	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
8	4	32	36	21	21	6	24	30	6	36	44	48	36	40	31	38	14	32	14	14	14	37	34
9	4	4	8	8	8	4	8	8	4	8	8	8	8	8	8	8	5	7	8	5	5	6	5
10	9	53	62	36	55	6	33	21	6	21	21	21	21	21	49	23	13	25	32	13	13	28	26
11	9	23	32	6	46	6	20	6	6	37	35	37	37	34	27	14	12	22	27	12	12	23	21
12	5	48	53	12	30	12	63	12	17	51	40	44	51	36	40	58	26	30	37	26	26	35	32
13	6	17	23	27	36	15	69	37	17	32	32	32	32	32	23	34	21	19	22	21	21	19	18
14	5	62	67	67	63	49	38	42	20	42	49	53	42	45	54	43	20	49	61	20	20	69	66
15	8	36	44	15	73	15	58	15	17	52	38	41	52	35	35	53	27	28	54	27	27	32	29
16	4	44	48	21	25	17	50	30	17	50	52	56	50	47	37	46	37	38	34	37	37	50	47
17	1	69	70	70	65	54	75	45	23	73	53	57	73	48	57	97	28	53	68	28	28	81	78
18	1	68	69	60	56	28	74	44	22	59	59	63	59	54	56	67	32	39	39	32	32	51	48
19	10	81	91	46	36	39	69	37	17	60	62	68	60	56	76	73	33	42	44	33	33	59	56
20	2	91	93	62	58	41	39	47	17	45	74	80	45	68	78	55	38	43	38	38	38	61	58
21	10	106	116	56	30	27	63	30	17	71	83	85	71	76	100	92	34	36	49	34	34	48	45
22	2	23	25	29	38	19	71	39	19	34	34	34	34	34	25	36	23	21	24	23	23	21	20
23	6	62	68	68	64	50	39	43	17	43	50	54	43	46	55	44	40	46	59	40	40	71	68
24	7	117	124	84	65	68	75	45	23	74	86	97	74	77	108	104	39	59	76	39	39	93	90
25	7	70	77	77	89	61	74	67	22	67	69	75	67	63	64	80	41	56	72	41	41	86	83
26	3	93	96	59	79	44	71	60	19	70	72	78	70	66	81	83	35	44	56	35	35	64	61
27	10	96	106	101	73	82	69	47	17	53	77	90	53	70	90	66	42	52	64	42	42	80	77
28	3	124	127	91	82	53	72	50	20	58	80	93	58	74	111	95	31	49	67	31	31	67	64
29	3	96	99	94	76	75	42	53	30	55	77	88	55	71	84	61	44	52	64	44	44	74	71
30	4	77	81	88	93	72	46	57	27	49	57	61	49	52	68	50	25	63	80	25	25	97	94
31	1	116	117	69	37	29	73	31	21	72	58	62	72	53	101	96	36	33	50	36	36	38	35
32	0	127	127	101	93	82	75	67	30	74	86	97	74	77	111	104	44	63	80	44	44	97	94

Network 1119
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	13	14	1	9	1	9	1	1	7	9	10	7	7	7	7	3	6	8	3	3	3	3
3	4	14	18	5	13	5	13	5	5	11	13	14	11	11	11	11	7	10	12	7	7	7	7
4	5	13	18	5	13	0	13	5	0	11	13	14	11	11	11	11	3	7	10	3	3	3	3
5	8	0	8	0	8	0	8	0	0	1	3	4	1	1	1	1	1	3	4	1	1	1	1
6	7	35	42	12	37	12	20	12	12	22	27	31	22	23	24	26	14	17	27	14	14	14	14
7	4	35	39	9	34	7	20	9	7	19	24	28	19	20	21	23	9	13	24	9	9	9	9
8	9	50	59	35	47	12	31	24	12	33	40	45	33	34	37	40	15	29	37	15	15	26	28
9	2	18	20	14	15	3	22	14	3	13	15	16	13	13	13	13	5	9	12	5	5	5	5
10	9	20	29	5	24	5	47	5	5	14	18	21	14	15	15	16	17	22	20	17	17	18	19
11	10	50	60	36	48	29	20	25	12	34	41	46	34	35	38	41	15	29	37	15	15	27	29
12	5	8	13	19	56	0	38	33	0	6	8	9	6	6	6	6	2	5	7	2	2	2	2
13	6	29	35	26	30	5	53	5	5	15	20	24	15	16	17	19	16	19	15	16	16	16	16
14	1	63	64	40	57	17	33	34	13	38	45	50	38	39	42	45	18	33	41	18	18	31	33
15	2	39	41	11	36	9	15	11	9	21	26	30	21	22	23	25	11	15	26	11	11	11	11
16	1	49	50	20	38	12	32	15	12	24	31	36	24	25	28	31	20	26	32	20	20	22	23
17	7	42	49	12	67	12	74	12	12	23	30	35	23	24	27	30	19	25	31	19	19	21	22
18	6	118	124	100	73	25	80	43	29	54	61	68	54	55	96	99	39	53	57	39	39	83	86
19	6	89	95	71	80	35	59	50	26	58	76	85	58	63	68	71	35	53	52	35	35	55	58
20	4	59	63	39	51	16	67	28	33	37	44	49	37	38	41	44	43	44	51	43	43	30	32
21	3	39	42	12	37	10	16	12	10	22	27	31	22	23	24	26	12	16	27	12	12	12	12
22	10	107	117	93	80	83	74	50	26	70	85	98	70	74	89	92	46	65	79	46	46	76	79
23	6	124	130	106	92	50	80	62	29	69	70	79	69	72	102	105	44	67	74	44	44	89	92
24	9	70	79	55	67	59	74	33	12	45	54	61	45	47	54	57	21	36	46	21	21	41	44
25	10	79	89	65	57	69	67	34	33	47	64	73	47	57	62	65	45	47	84	45	45	49	52
26	4	66	70	46	86	73	47	56	12	44	51	56	44	45	48	51	22	32	40	22	22	35	37
27	9	98	107	83	82	44	63	52	23	63	79	88	63	66	79	82	33	62	66	33	33	66	69
28	9	89	98	74	57	34	53	34	13	48	82	93	48	49	70	73	24	40	71	24	24	57	60
29	1	117	118	94	58	35	54	35	14	46	55	62	46	48	90	93	23	37	47	23	23	77	80
30	2	64	66	42	60	19	38	37	12	40	47	52	40	41	44	47	15	30	38	15	15	32	34
31	7	79	86	62	74	42	29	44	20	52	61	68	52	54	61	64	29	43	59	29	29	48	51
32	0	130	130	106	92	83	80	62	33	70	85	98	70	74	102	105	46	67	84	46	46	89	92

Network 1127
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
Low Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	8	9	17	8	8	8	8	8	8	24	27	30	24	25	27	28	16	19	25	16	16	21	21
4	10	9	19	0	10	0	10	0	0	17	22	27	17	19	21	23	9	14	22	9	9	15	15
5	4	0	4	19	14	19	14	14	14	4	4	4	4	4	4	4	4	6	4	4	4	4	4
6	2	52	54	2	16	2	16	2	2	19	24	29	19	21	23	25	12	16	24	12	12	17	17
7	4	48	52	27	20	0	20	18	0	9	10	11	9	9	9	9	6	8	9	6	6	7	7
8	5	4	9	0	25	0	31	0	0	5	6	7	5	5	5	5	5	2	7	5	5	5	5
9	9	81	90	15	0	15	0	0	0	20	31	38	20	22	33	35	10	19	33	10	10	27	27
10	7	54	61	34	46	19	42	25	14	35	46	53	35	43	40	50	27	39	45	27	27	44	43
11	6	61	67	40	31	2	26	31	2	46	52	59	46	36	53	56	21	29	48	21	21	41	40
12	10	71	81	54	56	37	42	41	14	56	65	74	56	57	67	70	28	42	58	28	28	50	49
13	4	19	23	23	39	23	35	10	10	24	28	33	24	26	27	29	16	23	28	16	16	21	21
14	4	67	71	6	35	6	46	6	6	28	35	42	28	30	57	39	20	27	37	20	20	31	31
15	5	94	99	65	61	47	55	46	23	66	75	84	66	64	77	80	36	49	66	36	36	59	58
16	9	23	32	8	70	8	70	8	8	36	55	64	36	59	47	60	22	32	53	22	22	38	37
17	10	38	48	19	81	19	80	14	14	10	13	16	10	11	13	14	7	11	14	7	7	11	11
18	9	104	113	79	90	64	55	56	23	76	87	97	76	78	94	96	44	68	75	44	44	74	72
19	10	133	143	113	61	86	55	46	23	81	96	110	81	86	115	116	39	58	88	39	39	95	93
20	4	90	94	44	100	27	50	72	29	40	39	46	40	47	44	43	26	36	41	26	26	35	35
21	7	146	153	120	118	96	80	79	23	91	106	120	91	96	125	126	43	64	95	43	43	105	103
22	2	113	115	81	92	66	90	64	25	78	89	99	78	80	96	98	50	71	77	50	50	76	74
23	3	143	146	102	96	89	83	68	37	84	99	113	84	89	118	119	42	61	91	42	42	98	96
24	9	116	125	91	70	76	70	46	23	80	93	105	80	83	105	106	38	55	83	38	38	85	83
25	8	125	133	99	70	55	70	46	23	67	78	88	67	84	85	87	37	52	70	37	37	67	65
26	5	99	104	70	111	42	50	84	29	61	70	79	61	69	72	75	31	44	61	31	31	54	53
27	5	104	109	75	86	60	88	51	34	72	83	93	72	74	90	92	48	69	75	48	48	72	70
28	1	153	154	103	71	97	84	47	15	92	107	121	92	97	126	127	29	65	96	29	29	106	104
29	3	113	116	82	93	67	87	65	18	79	90	100	79	81	97	99	47	71	78	47	47	77	75
30	4	54	58	31	43	31	39	22	18	32	43	50	32	40	37	47	30	40	45	30	30	45	44
31	6	32	38	60	106	2	61	62	2	16	19	22	16	17	19	20	8	3	17	8	8	13	13
32	0	154	154	120	118	97	90	84	37	92	107	121	92	97	126	127	50	71	96	50	50	106	104

Network 1200
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 1
High Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules						Buffered Schedules							Buffered Schedules						
				Low Level		High Level		Optimistic Schedules		Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	9	4	13	13	13	4	13	13	4	13	13	13	13	13	13	13	5	7	9	5	5	6	6
4	10	0	10	0	10	0	10	0	0	1	3	5	1	1	1	2	1	3	5	1	1	1	1
5	4	13	17	17	17	8	17	17	8	17	17	17	17	17	17	17	9	11	13	9	9	10	10
6	8	13	21	21	21	4	21	21	4	21	21	21	21	21	21	21	6	10	13	6	6	8	8
7	7	21	28	28	28	4	28	28	4	28	28	28	28	28	28	28	7	13	17	7	7	11	10
8	2	21	23	23	23	10	23	23	10	23	23	23	23	23	23	23	11	13	15	11	11	12	12
9	3	17	20	20	20	11	20	20	11	20	20	20	20	20	20	20	12	14	16	12	12	13	13
10	1	28	29	29	29	11	29	29	11	29	29	29	29	29	29	29	12	14	18	12	12	13	13
11	9	28	37	28	37	8	37	28	8	29	31	33	29	29	32	31	10	16	22	10	10	15	13
12	6	17	23	23	23	14	23	23	14	23	23	23	23	23	23	23	15	17	19	15	15	16	16
13	8	37	45	36	45	10	45	36	10	37	39	41	37	37	40	39	12	19	26	12	12	19	17
14	10	29	39	29	39	14	39	29	14	30	32	34	30	30	34	34	16	20	24	16	16	21	21
15	10	37	47	28	47	14	47	28	14	30	34	38	30	30	38	37	16	20	27	16	16	22	22
16	5	29	34	34	34	16	34	34	16	34	34	34	34	34	34	34	17	19	23	17	17	18	18
17	9	47	56	45	47	23	47	36	14	38	42	46	38	38	46	45	17	23	32	17	17	28	28
18	1	47	48	37	48	15	48	37	15	38	40	42	38	38	41	40	17	21	28	17	17	23	23
19	3	45	48	39	48	17	48	39	17	40	42	44	40	40	43	42	19	23	29	19	19	24	24
20	7	56	63	52	54	30	54	43	23	45	49	53	45	45	53	52	24	30	39	24	24	35	35
21	8	48	56	45	56	24	48	45	16	46	48	50	46	46	49	48	18	24	32	18	18	29	29
22	7	56	63	52	63	31	48	52	17	53	55	57	53	53	56	55	20	27	36	20	20	35	35
23	7	63	70	59	63	37	54	52	23	53	56	60	53	53	60	59	25	33	43	25	25	41	41
24	3	63	66	55	66	34	57	55	26	56	58	60	56	56	59	58	27	33	42	27	27	38	38
25	8	63	71	60	54	38	54	43	23	46	52	57	46	46	60	59	25	33	43	25	25	42	42
26	5	70	75	64	68	42	54	57	23	58	61	65	58	58	65	64	26	35	46	26	26	46	47
27	3	63	66	55	66	34	57	55	26	56	58	60	56	56	59	58	27	33	42	27	27	38	38
28	8	71	79	68	66	46	57	55	26	57	61	64	57	57	68	67	28	36	47	28	28	50	50
29	7	79	86	75	75	53	64	64	33	65	68	72	65	65	75	74	35	43	54	35	35	57	57
30	8	75	83	72	68	50	57	57	26	59	64	69	59	59	73	72	28	38	50	28	28	54	55
31	1	75	76	65	69	43	58	58	27	59	62	66	59	59	66	65	28	36	47	28	28	47	48
32	0	86	86	75	75	53	64	64	33	65	68	72	65	65	75	74	35	43	54	35	35	57	57

Network 1201
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules Low Level of Stochasticity							Buffered Schedules High Level of Stochasticity						
				Low Level		High Level																	
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	0	10	0	10	0	10	0	0	1	3	5	1	1	2	2	1	3	5	1	1	2	2
3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	8	10	18	0	18	0	18	0	0	2	6	9	2	2	4	5	2	6	9	2	2	4	5
6	4	0	4	4	4	0	4	4	0	4	4	4	4	4	4	4	1	2	2	1	1	1	4
7	3	10	13	6	13	3	13	6	3	6	6	8	6	6	6	6	4	4	7	4	4	4	6
8	3	18	21	7	21	3	21	7	3	7	9	12	7	7	7	8	4	7	11	4	4	5	8
9	2	21	23	9	23	5	23	9	5	9	11	14	9	9	9	10	6	9	13	6	6	7	10
10	3	18	21	7	21	6	21	7	6	7	9	12	7	7	7	8	6	9	12	6	6	7	8
11	2	10	12	6	12	3	12	6	3	6	6	7	6	6	6	6	4	4	6	4	4	4	6
12	3	23	26	12	26	9	26	12	9	12	14	17	12	12	12	13	9	12	16	9	9	10	13
13	7	23	30	9	30	6	30	9	6	10	14	18	10	10	12	14	7	12	17	7	7	10	14
14	5	18	23	6	23	3	23	6	3	7	8	12	7	7	8	8	5	8	12	5	5	6	8
15	1	23	24	10	24	6	24	10	6	10	12	15	10	10	10	11	7	10	14	7	7	8	11
16	6	30	36	18	36	15	36	18	15	18	20	24	18	18	18	20	15	18	23	15	15	16	20
17	10	30	40	22	30	19	30	12	9	13	17	23	13	13	18	21	10	15	22	10	10	16	21
18	3	30	33	15	33	12	33	15	12	15	17	21	15	15	15	17	12	15	20	12	12	13	17
19	9	36	45	27	36	24	36	18	15	19	23	29	19	19	24	27	16	21	28	16	16	22	27
20	5	45	50	32	41	29	36	23	15	24	28	34	24	24	29	32	17	23	31	17	17	26	32
21	1	40	41	23	37	20	37	19	16	19	21	25	19	19	19	22	16	19	24	16	16	17	22
22	6	45	51	33	42	30	36	24	15	25	29	35	25	25	30	33	17	23	31	17	17	27	33
23	7	41	48	30	44	27	37	26	16	26	28	32	26	26	26	29	17	22	28	17	17	22	29
24	7	50	57	39	48	36	36	30	15	31	35	41	31	31	36	39	18	26	35	18	18	32	39
25	8	51	59	41	44	38	37	26	16	27	32	39	27	27	37	40	18	26	35	18	18	34	40
26	1	51	52	34	43	31	38	25	17	26	30	36	26	26	31	34	18	24	32	18	18	28	34
27	4	57	61	43	52	40	42	34	21	35	39	45	35	35	40	43	22	30	39	22	22	36	43
28	5	61	66	48	57	45	47	39	26	40	44	50	40	40	45	48	27	35	44	27	27	41	48
29	3	59	62	44	51	41	40	33	19	34	38	44	34	34	40	43	21	29	38	21	21	37	43
30	9	66	75	57	57	54	47	39	26	41	47	55	41	41	54	57	28	38	49	28	28	50	57
31	5	62	67	49	56	46	45	38	24	39	43	49	39	39	45	48	26	34	43	26	26	42	48
32	0	75	75	57	57	54	47	39	26	41	47	55	41	41	54	57	28	38	49	28	28	50	57

Network 1212
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

				DH-Alogirhm Output Files: Project Task Completion Times																			
				Perfect Knowledge Schedules						Buffered Schedules							Buffered Schedules						
				Low Level		High Level		Optimistic Schedules		Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	10	0	10	0	10	0	10	0	0	1	3	5	1	1	5	2	1	3	5	1	1	2	2
3	2	10	12	2	12	2	12	2	2	3	5	7	3	3	7	4	3	5	7	3	3	4	4
4	9	10	19	0	19	0	19	0	0	2	6	10	2	2	10	5	2	6	10	2	2	4	4
5	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	8	0	8	8	8	0	8	8	0	8	8	8	8	8	8	8	1	3	4	1	1	1	1
7	8	12	20	10	20	2	20	10	2	11	13	15	11	11	15	12	4	8	11	4	4	6	7
8	4	19	23	12	23	6	23	12	6	12	12	14	12	12	14	12	7	10	14	7	7	8	8
9	4	19	23	6	23	6	23	6	6	7	10	14	7	7	14	9	7	10	14	7	7	8	8
10	10	23	33	12	33	6	33	12	6	13	15	19	13	13	19	16	8	13	19	8	8	13	13
11	10	33	43	12	43	6	43	12	6	14	18	24	14	14	24	22	9	16	24	9	9	18	19
12	7	20	27	17	27	2	27	17	2	18	20	22	18	18	22	19	5	11	15	5	5	9	10
13	6	23	29	16	29	12	29	16	12	17	19	21	17	17	21	18	13	16	20	13	13	14	14
14	8	23	31	20	31	6	31	20	6	20	21	23	20	20	23	20	8	13	18	8	8	11	11
15	7	43	50	24	50	13	43	24	6	25	27	31	25	25	31	29	10	19	28	10	10	22	24
16	2	43	45	22	45	8	45	22	8	22	23	26	22	22	26	24	11	18	26	11	11	20	21
17	3	43	46	19	46	15	46	19	15	20	22	27	20	20	27	25	16	19	27	16	16	21	22
18	10	50	60	34	50	25	46	24	15	26	30	36	26	26	36	36	17	22	33	17	17	29	32
19	9	50	59	33	59	22	43	33	12	34	36	40	34	34	40	38	14	22	33	14	14	28	30
20	1	50	51	25	51	16	47	25	16	26	28	32	26	26	32	30	17	20	29	17	17	23	25
21	5	60	65	39	56	30	52	30	21	31	35	41	31	31	41	41	22	27	38	22	22	34	37
22	8	60	68	42	67	33	46	41	15	42	44	48	42	42	48	46	18	25	37	18	18	36	39
23	8	60	68	42	59	33	47	33	16	35	39	44	35	35	44	45	18	25	37	18	18	35	39
24	3	65	68	42	62	33	55	36	24	37	39	44	37	37	44	44	25	30	41	25	25	37	40
25	9	68	77	51	67	42	52	41	21	43	47	53	43	43	53	55	23	30	43	23	23	44	48
26	2	68	70	44	69	35	54	43	23	44	46	50	44	44	50	48	24	29	40	24	24	38	41
27	5	77	82	56	74	47	55	48	24	49	52	58	49	49	58	60	28	34	46	28	28	49	53
28	3	77	80	54	70	45	58	44	27	46	50	56	46	46	56	58	28	33	46	28	28	47	51
29	2	68	70	44	69	35	57	43	26	44	46	50	44	44	50	48	27	32	43	27	27	39	42
30	8	82	90	64	74	55	58	48	27	50	55	62	50	50	62	68	29	37	50	29	29	57	61
31	7	70	77	51	76	42	64	50	33	51	53	57	51	51	57	55	34	39	50	34	34	46	49
32	0	90	90	64	76	55	64	50	33	51	55	62	51	51	62	68	34	39	50	34	34	57	61

Network 1222
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	9	0	9	0	9	0	0	1	3	5	1	1	2	2	1	3	5	1	1	2	2
3	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	7	0	7	7	7	0	7	7	0	7	7	7	7	7	7	7	1	3	4	1	1	1	1
5	1	9	10	1	10	1	10	1	1	2	4	6	2	2	3	3	2	4	6	2	2	3	3
6	6	9	15	13	15	4	15	13	4	13	13	13	13	13	13	13	5	6	8	5	5	5	6
7	2	10	12	9	12	6	12	9	6	9	9	9	9	9	9	9	6	6	8	6	6	6	6
8	7	15	22	13	22	4	22	13	4	14	16	17	14	14	16	15	6	9	12	6	6	8	8
9	6	10	16	13	16	10	16	13	10	13	13	13	13	13	13	13	10	10	12	10	10	10	10
10	8	22	30	13	30	6	30	13	6	15	19	21	15	15	20	19	7	12	16	7	7	12	12
11	6	15	21	19	21	6	21	19	6	19	19	19	19	19	19	19	7	8	11	7	7	8	8
12	9	15	24	13	24	4	24	13	4	14	16	18	14	14	17	17	6	9	13	6	6	9	10
13	6	30	36	25	36	6	36	25	6	25	25	27	25	25	26	25	8	14	19	8	8	15	15
14	1	30	31	14	31	11	31	14	11	16	20	22	16	16	21	20	11	13	17	11	11	13	13
15	2	22	24	21	24	12	24	21	12	21	21	21	21	21	21	21	12	12	14	12	12	12	12
16	1	36	37	26	37	12	37	26	12	26	26	28	26	26	27	26	12	15	20	12	12	16	16
17	2	31	33	23	33	14	33	23	14	23	23	24	23	23	23	23	14	15	19	14	14	15	15
18	2	37	39	28	39	14	39	28	14	28	28	30	28	28	29	28	14	17	22	14	14	18	18
19	3	36	39	28	39	13	36	28	10	28	28	30	28	28	29	28	11	15	21	11	11	17	17
20	3	39	42	31	42	17	42	31	17	31	31	33	31	31	32	31	17	20	25	17	17	21	21
21	10	37	47	36	47	24	37	36	14	36	36	38	36	36	37	36	15	18	25	15	15	22	22
22	1	42	43	32	43	18	43	32	18	32	32	34	32	32	33	32	18	21	26	18	18	22	22
23	2	47	49	38	49	26	41	38	16	38	38	40	38	38	39	38	17	20	27	17	17	24	24
24	10	43	53	42	43	28	43	32	18	33	35	39	33	33	40	38	19	24	31	19	19	29	29
25	7	49	56	45	56	33	43	45	18	45	45	47	45	45	46	45	19	24	31	19	19	30	29
26	6	49	55	44	55	32	48	44	23	44	44	46	44	44	45	44	23	26	33	23	23	30	30
27	10	55	65	54	55	42	48	44	23	45	47	51	45	45	54	52	24	29	38	24	24	39	38
28	10	65	75	64	56	52	48	45	23	46	50	56	46	46	64	62	25	32	43	25	25	49	48
29	7	56	63	52	63	40	48	52	23	52	52	54	52	52	53	52	24	29	37	24	24	37	36
30	10	56	66	55	56	43	43	45	18	46	48	52	46	46	56	54	20	27	36	20	20	40	39
31	4	47	51	40	51	28	47	40	22	40	40	42	40	40	41	40	22	25	30	22	22	26	26
32	0	75	75	64	63	52	48	52	23	52	52	56	52	52	64	62	25	32	43	25	25	49	48

Network 1225
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
Low Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
5	8	0	8	8	8	0	8	8	0	8	8	8	8	8	8	8	1	3	4	1	1	1	1
6	9	1	10	1	10	1	10	1	1	2	4	6	2	2	3	3	2	4	6	2	2	3	3
7	8	3	11	3	11	3	11	3	3	4	6	7	4	4	5	5	4	6	7	4	4	5	5
8	8	11	19	16	19	3	19	16	3	16	16	16	16	16	16	16	5	9	11	5	5	8	8
9	4	8	12	12	12	7	12	12	7	12	12	12	12	12	12	12	7	7	8	7	7	7	7
10	1	12	13	13	13	8	13	13	8	13	13	13	13	13	13	13	8	8	9	8	8	8	8
11	4	10	14	12	14	7	14	12	7	12	12	12	12	12	12	12	7	8	10	7	7	7	7
12	10	19	29	16	29	3	29	16	3	17	19	21	17	17	21	22	6	12	16	6	6	13	13
13	9	19	28	16	28	8	28	16	8	17	19	21	17	17	20	20	9	12	16	9	9	12	12
14	6	19	25	22	25	7	25	22	7	22	22	22	22	22	22	22	8	11	14	8	8	10	10
15	4	29	33	20	33	12	33	20	12	21	23	25	21	21	25	26	12	16	20	12	12	17	17
16	10	29	39	32	29	18	29	22	8	23	25	27	23	23	28	29	10	15	21	10	10	19	20
17	7	29	36	23	36	15	36	23	8	24	26	28	24	24	28	29	10	15	20	10	10	17	17
18	3	33	36	25	36	15	36	25	15	25	26	28	25	25	28	29	15	19	23	15	15	20	20
19	5	39	44	37	38	23	38	27	17	28	30	32	28	28	33	34	17	21	26	17	17	24	25
20	6	39	45	38	42	24	36	29	12	30	32	34	30	30	34	35	13	18	24	13	13	23	25
21	3	44	47	40	41	26	41	30	20	31	33	35	31	31	36	37	20	24	29	20	20	27	28
22	5	45	50	43	47	29	38	34	17	35	37	39	35	35	39	40	18	23	29	18	18	28	29
23	1	44	45	38	39	24	39	28	18	29	31	33	29	29	34	35	18	22	27	18	18	25	26
24	10	45	55	48	42	34	36	29	15	31	35	39	31	31	42	43	16	22	29	16	16	31	33
25	6	55	61	54	47	40	41	34	20	36	39	42	36	36	48	49	21	26	32	21	21	37	39
26	4	47	51	44	46	30	45	34	24	35	37	39	35	35	40	41	24	28	33	24	24	31	32
27	5	55	60	53	47	39	43	34	22	36	40	44	36	36	47	48	22	27	34	22	22	36	38
28	4	61	65	58	51	44	43	38	22	40	44	48	40	40	52	53	23	29	36	23	23	41	43
29	5	65	70	63	56	49	45	43	24	45	49	53	45	45	57	58	25	31	39	25	25	46	48
30	9	61	70	63	47	49	45	34	24	39	42	47	39	39	57	58	25	31	38	25	25	46	48
31	3	50	53	46	50	32	44	37	23	38	40	42	38	38	42	43	23	27	32	23	23	31	32
32	0	70	70	63	56	49	45	43	24	45	49	53	45	45	57	58	25	31	39	25	25	46	48

Network 1300
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

DH-Algorithm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	7	5	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
4	5	5	10	16	10	5	10	16	5	10	10	10	10	10	10	10	6	7	8	6	6	6	6
5	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	6	10	16	11	16	5	16	11	5	16	16	16	16	16	16	16	7	9	11	7	7	7	7
7	9	29	38	16	38	12	38	16	12	21	25	29	21	23	24	24	14	18	22	14	14	17	17
8	3	26	29	19	29	12	29	19	12	20	22	24	20	21	21	21	15	19	24	15	15	18	18
9	10	16	26	16	26	12	26	16	12	17	19	21	17	18	18	18	13	15	17	13	13	14	14
10	6	48	54	25	54	18	54	25	18	28	34	40	28	31	34	34	22	28	35	22	22	28	28
11	10	38	48	19	48	12	48	19	12	22	28	34	22	25	28	28	16	22	29	16	16	22	22
12	8	54	62	33	62	26	62	33	26	36	42	48	36	39	42	42	30	36	43	30	30	36	36
13	5	48	53	24	53	17	53	24	17	27	33	39	27	30	33	33	21	27	34	21	21	27	27
14	6	54	60	31	60	24	60	37	24	34	40	46	34	37	40	40	28	34	41	28	28	34	34
15	6	60	66	37	66	18	66	31	18	40	46	52	40	43	46	46	29	36	44	29	29	38	37
16	1	75	76	44	67	33	67	38	27	42	50	58	42	46	53	52	32	40	50	32	32	45	43
17	6	76	82	43	62	32	62	37	26	43	52	61	43	47	57	56	33	42	53	33	33	49	47
18	9	66	75	33	76	26	76	37	26	41	49	57	41	45	52	51	31	39	49	31	31	44	42
19	3	82	85	47	81	36	67	43	27	48	57	64	48	52	60	59	36	45	55	36	36	51	49
20	2	85	87	49	78	38	78	40	29	45	54	66	45	49	62	61	35	44	57	35	35	53	51
21	8	87	95	57	86	46	86	48	37	53	62	74	53	57	70	69	43	52	65	43	43	61	59
22	3	85	88	50	86	39	79	48	30	54	62	67	54	59	63	62	40	52	58	40	40	54	52
23	2	98	100	62	83	51	78	45	29	51	59	74	51	56	73	72	41	46	64	41	41	64	62
24	10	88	98	60	67	49	67	38	27	49	65	72	49	54	71	70	37	49	63	37	37	62	60
25	3	100	103	65	94	54	89	56	40	62	73	82	62	67	76	75	47	57	71	47	47	67	65
26	10	103	113	75	86	64	86	48	37	63	76	87	63	68	85	84	48	60	76	48	48	76	74
27	5	117	122	84	91	73	86	53	37	59	70	79	59	64	94	93	44	54	68	44	44	85	83
28	9	122	131	93	94	82	89	56	40	68	83	96	68	73	103	102	53	67	85	53	53	94	92
29	5	131	136	98	99	87	89	61	40	73	88	101	73	78	108	107	54	69	88	54	54	99	97
30	2	113	115	77	96	66	91	58	42	65	78	89	65	70	87	86	50	62	78	50	50	78	76
31	4	113	117	79	103	68	93	65	44	67	80	91	67	72	89	88	52	64	80	52	52	80	78
32	0	136	136	98	103	87	93	65	44	73	88	101	73	78	108	107	54	69	88	54	54	99	97

Network 1304
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

				DH-Alogirhm Output Files: Project Task Completion Times																			
				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	7	0	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
3	3	8	11	3	11	3	11	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	8	0	8	0	8	0	8	0	0	4	6	7	4	5	4	4	4	6	7	4	4	4	4
5	6	18	24	14	24	7	24	14	7	14	15	18	14	14	14	14	9	13	15	9	9	10	9
6	7	11	18	7	18	7	18	7	7	15	18	12	15	15	16	16	10	11	12	10	10	12	10
7	2	25	27	5	27	5	27	5	5	6	8	20	6	7	6	6	6	15	17	6	6	6	6
8	1	24	25	8	25	13	25	8	13	8	9	8	8	8	8	8	8	8	8	8	8	8	8
9	3	27	30	17	30	7	30	17	7	18	21	23	18	18	19	19	11	19	22	11	11	13	11
10	10	30	40	17	40	13	40	17	13	19	24	28	19	20	22	23	17	22	27	17	17	21	19
11	5	40	45	22	45	12	45	22	12	24	29	33	24	25	27	28	16	18	20	16	16	18	16
12	10	40	50	27	50	13	50	27	13	29	34	38	29	30	32	33	12	18	32	12	12	17	15
13	5	45	50	27	50	18	50	27	18	29	34	38	29	30	32	33	23	30	32	23	23	30	28
14	8	50	58	27	58	13	58	27	13	30	37	42	30	32	36	37	18	25	36	18	18	25	23
15	7	58	65	34	65	13	65	34	13	37	44	49	37	39	43	44	24	33	40	24	24	34	32
16	7	58	65	34	65	25	65	34	25	37	44	49	37	39	43	44	30	37	43	30	30	37	35
17	1	65	66	35	66	26	66	35	26	38	45	50	38	40	44	45	31	38	44	31	31	38	36
18	5	65	70	39	70	30	70	39	30	42	49	54	42	44	48	49	35	42	48	35	35	42	40
19	3	80	83	52	73	43	66	42	26	46	55	62	46	49	58	59	37	46	55	37	37	51	48
20	10	70	80	49	66	40	66	35	26	43	52	59	43	46	55	56	36	45	53	36	36	49	46
21	1	83	84	53	74	44	71	43	31	47	56	63	47	50	59	60	38	47	56	38	38	52	49
22	4	83	87	56	77	47	80	46	40	50	59	66	50	53	62	63	41	50	59	41	41	55	52
23	1	93	94	63	78	54	81	47	41	57	66	73	57	60	69	70	48	57	66	48	48	62	59
24	4	87	91	60	82	51	80	51	40	54	63	70	54	57	66	67	42	52	61	42	42	58	55
25	6	87	93	62	84	53	76	53	36	56	65	72	56	59	68	69	47	56	65	47	47	61	58
26	6	102	108	77	82	68	81	51	41	59	71	80	59	62	81	83	50	62	73	50	50	74	70
27	8	94	102	71	84	62	80	53	40	58	69	77	58	61	76	77	49	60	70	49	49	69	65
28	9	108	117	86	93	77	81	62	41	68	80	89	68	71	90	92	51	65	78	51	51	82	78
29	4	117	121	90	97	81	81	66	41	72	84	93	72	75	94	96	52	67	80	52	52	86	82
30	9	121	130	99	106	90	90	75	50	81	93	102	81	84	103	105	61	76	89	61	61	95	91
31	9	121	130	99	84	90	81	53	41	73	87	98	73	77	103	105	53	70	85	53	53	95	91
32	0	130	130	99	106	90	90	75	50	81	93	102	81	84	103	105	61	76	89	61	61	95	91

Network 1308
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	4	3	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
4	6	7	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
5	6	0	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
6	7	19	26	20	26	13	26	20	13	26	26	26	26	26	26	26	15	18	20	15	15	16	15
7	2	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
8	4	26	30	24	30	17	30	24	17	30	30	30	30	30	30	30	19	22	24	19	19	20	19
9	6	13	19	30	19	13	19	30	13	19	19	19	19	19	19	19	14	15	16	14	14	14	14
10	10	37	47	24	50	17	50	24	17	32	36	39	32	33	36	34	21	28	33	21	21	26	24
11	10	47	57	30	40	17	40	30	17	33	39	44	33	35	40	38	22	31	38	22	22	30	28
12	10	57	67	40	67	17	67	40	17	43	49	54	43	45	50	48	23	34	43	23	23	35	33
13	7	30	37	30	57	13	57	30	13	31	33	34	31	31	32	31	20	25	28	20	20	22	21
14	10	68	78	40	77	17	77	40	17	45	53	60	45	48	57	55	25	38	49	25	25	42	40
15	7	78	85	48	67	25	67	40	17	46	56	64	46	49	62	60	26	41	53	26	26	47	45
16	9	57	66	39	66	17	66	39	17	42	48	53	42	44	49	47	23	34	43	23	23	34	32
17	6	87	93	56	77	33	77	40	17	49	60	69	49	52	68	67	29	45	58	29	29	53	52
18	7	93	100	63	84	40	77	48	17	56	67	76	56	59	75	74	30	48	62	30	30	58	58
19	2	85	87	50	91	27	79	54	19	48	58	66	48	51	64	62	28	43	55	28	28	49	47
20	4	100	104	67	89	44	77	52	17	60	71	80	60	63	79	78	31	50	64	31	31	61	62
21	10	104	114	77	84	54	77	48	17	61	74	85	61	65	87	87	32	53	69	32	32	69	71
22	1	67	68	41	85	18	80	41	20	44	50	55	44	46	51	49	24	35	44	24	24	36	34
23	1	120	121	84	98	61	81	61	21	68	81	92	68	72	94	94	34	56	73	34	34	75	78
24	6	114	120	83	97	60	80	60	20	67	80	91	67	71	93	93	33	55	72	33	33	74	77
25	4	125	129	92	106	69	89	69	29	76	89	100	76	80	102	102	42	64	81	42	42	83	86
26	4	121	125	88	102	65	85	65	25	72	85	96	72	76	98	98	38	60	77	38	38	79	82
27	7	121	128	91	105	68	88	68	28	75	88	99	75	79	101	101	41	63	80	41	41	82	85
28	9	129	138	101	106	78	89	69	29	77	92	105	77	82	111	111	43	67	86	43	43	92	95
29	4	141	145	108	110	85	93	73	33	84	99	112	84	89	118	118	48	72	92	48	48	99	102
30	8	138	146	109	114	86	97	77	37	85	100	113	85	90	119	119	51	75	94	51	51	100	103
31	3	138	141	104	113	81	89	76	29	80	95	108	80	85	114	114	44	68	88	44	44	95	98
32	0	146	146	109	114	86	97	77	37	85	100	113	85	90	119	119	51	75	94	51	51	100	103

Network 1314
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
3	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4	5	3	8	8	8	3	8	8	3	8	8	8	8	8	8	8	4	5	6	4	4	4	4
5	2	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
6	3	8	11	11	11	0	11	11	0	11	11	11	11	11	11	11	5	8	11	5	5	5	5
7	6	11	17	17	17	5	17	17	5	17	17	17	17	17	17	17	6	7	9	6	6	7	6
8	4	27	31	21	31	11	31	21	11	22	24	26	22	23	24	23	12	14	18	12	12	20	17
9	6	31	37	17	37	5	37	17	5	23	26	29	23	24	26	25	7	10	14	7	7	9	8
10	7	37	44	21	44	11	44	21	11	24	29	33	24	25	29	28	14	20	27	14	14	23	23
11	10	17	27	11	27	7	27	11	7	18	20	22	18	19	20	19	13	17	23	13	13	12	20
12	9	44	53	11	53	7	53	11	7	25	32	38	25	27	33	33	8	23	32	8	8	16	13
13	3	53	56	30	56	11	56	25	11	28	35	41	28	30	36	36	15	24	34	15	15	25	25
14	2	56	58	23	58	13	58	27	13	30	37	43	30	32	38	38	17	26	36	17	17	27	27
15	1	62	63	31	63	18	63	22	18	35	42	48	35	37	43	43	22	31	41	22	22	32	32
16	6	56	62	27	62	17	62	31	17	34	41	47	34	36	42	42	21	30	40	21	21	31	31
17	6	65	71	37	71	26	69	37	24	43	50	56	43	45	51	51	30	39	49	30	30	40	40
18	3	58	61	33	61	16	61	30	16	33	40	46	33	35	41	41	20	29	39	20	20	30	30
19	10	71	81	47	63	36	63	31	18	44	53	61	44	47	58	58	31	42	54	31	31	47	47
20	2	81	83	49	73	38	69	41	24	46	55	63	46	49	60	60	32	43	55	32	32	49	49
21	2	63	65	51	65	20	71	39	26	37	44	50	37	39	45	45	24	33	43	24	24	34	34
22	8	83	91	59	81	46	71	49	26	54	63	71	54	57	68	68	33	46	59	33	33	56	56
23	6	83	89	57	79	44	71	47	26	52	61	69	52	55	66	66	33	45	58	33	33	54	54
24	10	95	105	73	81	60	71	49	26	55	70	80	55	63	81	81	34	53	68	34	34	69	69
25	1	95	96	64	82	51	72	50	27	55	68	76	55	62	73	73	34	51	64	34	34	61	61
26	1	105	106	74	86	61	73	54	28	60	71	81	60	64	82	82	39	54	69	39	39	70	70
27	3	106	109	77	85	64	76	53	31	63	74	84	63	67	85	85	42	57	72	42	42	73	73
28	5	113	118	86	85	73	76	53	31	65	78	89	65	69	94	94	44	61	77	44	44	82	82
29	4	118	122	90	94	77	76	62	31	69	82	93	69	73	98	98	45	63	79	45	45	86	86
30	4	109	113	81	86	68	73	54	28	64	76	86	64	68	89	89	43	59	74	43	43	77	77
31	4	91	95	63	90	50	80	58	35	59	67	75	59	61	72	72	38	50	63	38	38	60	60
32	0	122	122	90	94	77	80	62	35	69	82	93	69	73	98	98	45	63	79	45	45	86	86

Network 1325
N = 30
Resource Types = 2
Max Units of Available of Each Resource Type = 10
High Network Parameters
High Resource Paramters
DH Solution Summaries

DH-Alogirhm Output Files: Project Task Completion Times

				Perfect Knowledge Schedules				Optimistic Schedules		Buffered Schedules							Buffered Schedules						
				Low Level		High Level				Low Level of Stochasticity							High Level of Stochasticity						
Activity Number	Activity Duration	Pessimistic Schedule Start Time	Pessimistic Schedule End Time	LL	EL	LH	EH	OL	OH	10%	30%	50%	JG3	JG4	JG5	JG6	10%	30%	50%	JG3	JG4	JG5	JG6
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
3	10	0	10	10	10	0	10	10	0	10	10	10	10	10	10	10	1	3	5	1	1	2	2
4	3	10	13	13	13	8	13	13	8	15	15	15	15	15	15	15	10	10	10	10	10	10	10
5	6	0	6	6	6	0	6	6	0	6	6	6	6	6	6	6	1	2	3	1	1	1	1
6	8	6	14	5	14	5	14	5	5	7	9	10	7	7	8	7	8	10	11	8	8	9	9
7	2	14	16	15	16	10	16	15	10	12	12	12	12	12	12	12	7	7	7	7	7	7	7
8	9	16	25	13	25	8	25	13	8	17	21	24	17	18	22	22	12	16	28	12	12	17	17
9	8	32	40	13	40	8	40	13	8	18	24	28	18	19	25	25	13	19	19	13	13	20	21
10	7	25	32	29	32	10	32	29	10	25	31	35	25	26	32	32	14	22	15	14	14	22	24
11	8	40	48	13	48	8	48	13	8	16	18	19	16	16	19	19	11	13	23	11	11	14	14
12	7	51	58	22	58	10	55	22	10	32	38	42	32	33	39	39	15	25	35	15	15	26	28
13	3	58	61	35	61	16	61	35	16	38	44	48	38	39	45	45	21	31	38	21	21	32	34
14	3	48	51	32	51	13	58	32	13	35	41	45	35	36	42	42	18	28	31	18	18	29	31
15	8	58	66	40	66	21	66	40	21	43	49	53	43	44	50	50	26	36	43	26	26	37	39
16	1	61	62	36	62	17	62	36	17	39	45	49	39	40	46	46	22	32	39	22	22	33	35
17	7	62	69	43	69	24	61	43	16	46	52	56	46	47	53	53	23	35	43	23	23	37	39
18	2	76	78	52	78	33	73	52	28	55	61	65	55	56	62	62	33	45	49	33	33	44	46
19	1	78	79	53	79	34	74	53	29	56	62	66	56	57	63	63	34	46	50	34	34	45	47
20	7	69	76	50	76	31	61	50	16	53	59	63	53	54	60	60	24	38	47	24	24	42	44
21	5	79	84	58	84	39	71	58	26	61	67	71	61	62	68	68	31	43	55	31	31	50	52
22	7	87	94	68	94	49	73	68	28	71	77	81	71	72	78	78	35	49	62	35	35	58	60
23	3	84	87	61	87	42	77	61	32	64	70	74	64	65	71	71	38	52	58	38	38	53	55
24	3	94	97	71	97	52	80	71	35	74	80	84	74	75	81	81	41	55	65	41	41	61	63
25	8	103	111	85	97	66	80	71	35	81	89	94	81	83	94	92	43	60	72	43	43	73	75
26	4	111	115	89	101	70	84	75	39	85	93	98	85	87	98	96	47	64	76	47	47	77	79
27	6	97	103	77	107	58	77	81	32	80	86	90	80	81	87	87	42	57	68	42	42	66	68
28	10	115	125	99	107	80	80	81	35	86	96	103	86	89	107	104	48	67	81	48	48	86	88
29	7	132	139	113	97	94	80	71	35	94	106	114	94	97	121	117	56	77	92	56	56	100	102
30	10	139	149	123	107	104	84	81	39	95	109	119	95	99	131	127	57	80	97	57	57	110	112
31	7	125	132	106	114	87	91	88	46	93	103	110	93	96	114	111	55	74	88	55	55	93	95
32	0	149	149	123	114	104	91	88	46	95	109	119	95	99	131	127	57	80	97	57	57	110	112

APPENDIX I
DURATION METRIC CALULATIONS - PHASE ONE EXPERIMENT

Phase One Duration Metric Summary
1000 Networks – Low Stochasticity Level

		Infeasible Baseline Schedules								
Network 1004		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		44	30	30	30	32	30	30	34	34
LL	35	-20%	17%	17%	17%	9%	17%	17%	3%	3%
EL	39	-11%	30%	30%	30%	22%	30%	30%	15%	15%

		Infeasible Baseline Schedules								
Network 1010		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		41	41	41	41	41	41	41	41	41
LL	41	0%	0%	0%	0%	0%	0%	0%	0%	0%
EL	41	0%	0%	0%	0%	0%	0%	0%	0%	0%

		Infeasible Baseline Schedules								
Network 1015		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		39	25	25	25	27	25	25	34	33
LL	34	-13%	36%	36%	36%	26%	36%	36%	0%	3%
EL	30	-23%	20%	20%	20%	11%	20%	20%	-12%	-9%

		Infeasible Baseline Schedules								
Network 1020		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		40	29	29	30	32	29	29	34	35
LL	33	-18%	14%	14%	10%	3%	14%	14%	-3%	-6%
EL	34	-15%	17%	17%	13%	6%	17%	17%	0%	-3%

		Infeasible Baseline Schedules								
Network 1028		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		42	27	28	30	31	28	28	32	33
LL	34	-19%	26%	21%	13%	10%	21%	21%	6%	3%
EL	35	-17%	30%	25%	17%	13%	25%	25%	9%	6%

Summary Phase One Experiment Duration Metric Values - 1000 Networks Low Stochasticity Level

	Infeasible Baseline Schedules								
Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LL	14%	18%	18%	15%	10%	18%	18%	2%	3%
EL	13%	19%	18%	16%	10%	18%	18%	7%	7%

1100 Networks – Low Stochasticity Level

Network 1102		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		124	58	65	81	92	65	68	97	101
LL	96	-23%	66%	48%	19%	4%	48%	41%	-1%	-5%
EL	89	-28%	53%	37%	10%	-3%	37%	31%	-8%	-12%

Network 1105		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		130	76	83	95	103	83	86	108	111
LL	107	-18%	41%	29%	13%	4%	29%	24%	-1%	-4%
EL	99	-24%	30%	19%	4%	-4%	19%	15%	-8%	-11%

Network 1112		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		127	67	74	86	97	74	77	111	104
LL	101	-20%	51%	36%	17%	4%	36%	31%	-9%	-3%
EL	93	-27%	39%	26%	8%	-4%	26%	21%	-16%	-11%

Network 1119		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		130	62	70	85	98	70	74	102	105
LL	106	-18%	71%	51%	25%	8%	51%	43%	4%	1%
EL	92	-29%	48%	31%	8%	-6%	31%	24%	-10%	-12%

Network 1127		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		154	84	92	107	121	92	97	126	127
LL	120	-22%	43%	30%	12%	-1%	30%	24%	-5%	-6%
EL	118	-23%	40%	28%	10%	-2%	28%	22%	-6%	-7%

Summary Phase One Experiment Duration Metric Values - 1100 Networks Low Stochasticity Level

Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
	Infeasible Baseline Schedules								
LL	20%	54%	39%	17%	4%	39%	33%	4%	4%
EL	26%	42%	28%	8%	4%	28%	23%	10%	11%

1200 Networks – Low Stochasticity Level

Network 1200		Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		86	64	65	68	72	65	76	75	74
LL	75	-13%	17%	15%	10%	4%	15%	-1%	0%	1%
EL	75	-13%	17%	15%	10%	4%	15%	-1%	0%	1%

Network 1201		Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		75	39	41	47	55	41	41	54	57
LL	57	-24%	46%	39%	21%	4%	39%	39%	6%	0%
EL	57	-24%	46%	39%	21%	4%	39%	39%	6%	0%

Network 1212		Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LL	64	-29%	28%	25%	16%	3%	25%	25%	3%	-6%
EL	76	-16%	52%	49%	38%	23%	49%	49%	23%	12%

Network 1222		Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		75	52	52	52	56	52	52	64	62
LL	64	-15%	23%	23%	23%	14%	23%	23%	0%	3%
EL	63	-16%	21%	21%	21%	13%	21%	21%	-2%	2%

Network 1225		Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		70	43	45	49	53	45	45	57	58
LL	63	-10%	47%	40%	29%	19%	40%	40%	11%	9%
EL	56	-20%	30%	24%	14%	6%	24%	24%	-2%	-3%

Summary Phase One Experiment Duration Metric Values - 1200 Networks Low Stochasticity Level

Perfect Knowledge Schedules	Infeasible Baseline Schedules: Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LL	18%	32%	29%	20%	9%	29%	26%	4%	4%
EL	18%	33%	30%	21%	10%	30%	27%	6%	4%

1300 Networks – Low Stochasticity Level

		Infeasible Baseline Schedules								
Network 1300		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		136	65	73	88	101	73	78	108	107
LL	98	-28%	51%	34%	11%	-3%	34%	26%	-9%	-8%
EL	103	-24%	58%	41%	17%	2%	41%	32%	-5%	-4%

		Infeasible Baseline Schedules								
Network 1304		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		130	75	81	93	102	81	84	103	105
LL	99	-24%	32%	22%	6%	-3%	22%	18%	-4%	-6%
EL	106	-18%	41%	31%	14%	4%	31%	26%	3%	1%

		Infeasible Baseline Schedules								
Network 1308		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		146	77	85	100	113	85	90	119	119
LL	109	-25%	42%	28%	9%	-4%	28%	21%	-8%	-8%
EL	114	-22%	48%	34%	14%	1%	34%	27%	-4%	-4%

		Infeasible Baseline Schedules								
Network 1314		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		122	62	69	82	93	69	73	98	98
LL	90	-26%	45%	30%	10%	-3%	30%	23%	-8%	-8%
EL	94	-23%	52%	36%	15%	1%	36%	29%	-4%	-4%

		Infeasible Baseline Schedules								
Network 1325		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		149	88	95	109	119	95	99	131	127
LL	123	-17%	40%	29%	13%	3%	29%	24%	-6%	-3%
EL	114	-23%	30%	20%	5%	-4%	20%	15%	-13%	-10%

Summary Phase One Experiment Duration Metric Values - 1300 Networks Low Stochasticity Level

	Infeasible Baseline Schedules								
Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LL	24%	42%	29%	10%	3%	29%	22%	7%	7%
EL	22%	46%	32%	13%	2%	32%	26%	6%	5%

Phase One Duration Metric Summary
1000 Networks – High Stochasticity Level

Network 1004		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		44	11	15	21	27	15	15	29	29
LH	24	-45%	118%	60%	14%	-11%	60%	60%	-17%	-17%
EH	31	-30%	182%	107%	48%	15%	107%	107%	7%	7%

Network 1010		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		41	12	12	18	23	12	12	27	26
LH	19	-54%	58%	58%	6%	-17%	58%	58%	-30%	-27%
EH	32	-22%	167%	167%	78%	39%	167%	167%	19%	23%

Network 1015		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		39	14	15	19	24	15	15	30	30
LH	25	-36%	79%	67%	32%	4%	67%	67%	-17%	-17%
EH	28	-28%	100%	87%	47%	17%	87%	87%	-7%	-7%

Network 1020		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		40	21	22	24	26	22	22	29	30
LH	28	-30%	33%	27%	17%	8%	27%	27%	-3%	-7%
EH	33	-18%	57%	50%	38%	27%	50%	50%	14%	10%

Network 1028		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
		Infeasible Baseline Schedules								
Perfect Knowledge Schedules Final Duration Values		42	10	13	18	24	13	13	27	27
LH	28	-33%	180%	115%	56%	17%	115%	115%	4%	4%
EH	24	-43%	140%	85%	33%	0%	85%	85%	-11%	-11%

Summary Phase One Experiment Duration Metric Values - 1000 Networks High Stochasticity Level

Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
	Infeasible Baseline Schedules								
LH	40%	94%	66%	25%	11%	66%	66%	14%	14%
EH	28%	129%	99%	49%	20%	99%	99%	11%	12%

1100 Networks – High Stochasticity

Network 1102		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		124	25	36	58	77	36	36	88	86
LH	78	-37%	212%	117%	34%	1%	117%	117%	-11%	-9%
EH	69	-44%	176%	92%	19%	-10%	92%	92%	-22%	-20%

Network 1105		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		130	29	45	69	81	45	45	94	91
LH	87	-33%	200%	93%	26%	7%	93%	93%	-7%	-4%
EH	72	-45%	148%	60%	4%	-11%	60%	60%	-23%	-21%

Network 1112		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		127	30	44	63	80	44	44	97	94
LH	82	-35%	173%	86%	30%	3%	86%	86%	-15%	-13%
EH	75	-41%	150%	70%	19%	-6%	70%	70%	-23%	-20%

Network 1119		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		130	33	46	67	84	46	46	90	93
LH	83	-36%	152%	80%	24%	-1%	80%	80%	-8%	-11%
EH	80	-38%	142%	74%	19%	-5%	74%	74%	-11%	-14%

Network 1127		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		154	37	50	71	96	50	50	106	104
LH	97	-37%	162%	94%	37%	1%	94%	94%	-8%	-7%
EH	90	-42%	143%	80%	27%	-6%	80%	80%	-15%	-13%

Summary Phase One Experiment Duration Metric Values - 1100 Networks High Stochasticity Level

	Infeasible Baseline Schedules								
Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LH	36%	180%	94%	30%	3%	94%	94%	10%	9%
EH	42%	152%	75%	18%	8%	75%	75%	19%	18%

1200 Networks – High Stochasticity

Network 1200		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		86	33	35	43	54	35	35	57	57
LH	53	-38%	61%	51%	23%	-2%	51%	51%	-7%	-7%
EH	64	-26%	94%	83%	49%	19%	83%	83%	12%	12%

Network 1201		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		75	26	28	38	49	28	28	50	57
LH	54	-28%	108%	93%	42%	10%	93%	93%	8%	-5%
EH	47	-37%	81%	68%	24%	-4%	68%	68%	-6%	-18%

Network 1212		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		90	33	34	39	50	34	34	57	61
LH	55	-39%	67%	62%	41%	10%	62%	62%	-4%	-10%
EH	64	-29%	94%	88%	64%	28%	88%	88%	12%	5%

Network 1222		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		75	23	25	32	43	25	25	49	48
LH	52	-31%	126%	108%	63%	21%	108%	108%	6%	8%
EH	48	-36%	109%	92%	50%	12%	92%	92%	-2%	0%

Network 1225		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		70	24	25	31	39	25	25	46	48
LH	49	-30%	104%	96%	58%	26%	96%	96%	7%	2%
EH	45	-36%	88%	80%	45%	15%	80%	80%	-2%	-6%

Summary Phase One Experiment Duration Metric Values - 1200 Networks High Stochasticity Level

	Infeasible Baseline Schedules								
Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LH	33%	93%	82%	45%	14%	82%	82%	6%	7%
EH	33%	93%	82%	46%	16%	82%	82%	7%	8%

1300 Networks – High Stochasticity

Network 1300		Infeasible Baseline Schedules								
		Scheduling Approach Final Duration Values								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		136	44	54	69	88	54	54	99	97
LH	87	-36%	98%	61%	26%	-1%	61%	61%	-12%	-10%
EH	93	-32%	111%	72%	35%	6%	72%	72%	-6%	-4%

Network 1304		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		130	50	61	76	89	61	61	95	91
LH	90	-31%	80%	48%	18%	1%	48%	48%	-5%	-1%
EH	90	-31%	80%	48%	18%	1%	48%	48%	-5%	-1%

Network 1308		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		146	37	51	75	94	51	51	100	103
LH	86	-41%	132%	69%	15%	-9%	69%	69%	-14%	-17%
EH	97	-34%	162%	90%	29%	3%	90%	90%	-3%	-6%

Network 1314		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		122	35	45	63	79	45	73	86	86
LH	77	-37%	120%	71%	22%	-3%	71%	5%	-10%	-10%
EH	80	-34%	129%	78%	27%	1%	78%	10%	-7%	-7%

Network 1325		Infeasible Baseline Schedules								
		Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
Perfect Knowledge Schedules Final Duration Values		149	46	57	80	97	57	57	110	112
LH	104	-30%	126%	82%	30%	7%	82%	82%	-5%	-7%
EH	91	-39%	98%	60%	14%	-6%	60%	60%	-17%	-19%

Summary Phase One Experiment Duration Metric Values - 1300 Networks High Stochasticity Level

	Infeasible Baseline Schedules								
Perfect Knowledge Schedules	Pessimistic	Optimistic	10% Buffer	30% Buffer	50% Buffer	JG3 Buffer	JG4 Buffer	JG5 Buffer	JG6 Buffer
LH	35%	111%	66%	22%	4%	66%	53%	9%	9%
EH	34%	116%	69%	25%	3%	69%	56%	8%	7%

APPENDIX J
STABILITY METRIC CALCULATIONS – PHASE ONE EXPERIMENT

	Stability Metric Calculations Phase One Experiment Low Stochasticity Level Infeasible Baseline Schedule to Perfect Knowledge Schedule								
Network	Pess	Opt	10%	30%	50%	JG3	JG4	JG5	JG6
1000	2	3	4	5	6	7	8	9	10
1100	20	21	22	23	24	25	26	27	28
1200	38	39	40	41	42	43	44	45	46
1300	56	57	58	59	60	61	62	63	64

	Stability Metric Calculations Phase One Experiment High Stochasticity Level Infeasible Baseline Schedule to Perfect Knowledge Schedule								
Network	Pess	Opt	10%	30%	50%	JG3	JG4	JG5	JG6
1000	11	12	13	14	15	16	17	18	19
1100	29	30	31	32	33	34	35	36	37
1200	47	48	49	50	51	52	53	54	55
1300	65	66	67	68	69	70	71	72	73

APPENDIX K
GANTT CHARTS-PHASE TWO EXPERIMENT
LOW STOCHASTICITY

GANTT CHARTS
LOW LEVEL OF STOCHASTICITY

	50% Partial Buffer Size				JG5 Partial Buffer Size				JG6 Partial Buffer Size			
Network Number	Raw Data	Infeas Base	Infeas to EL	Infeas to LL	Raw Data	Infeas Base	Infeas to EL	Infeas to LL	Raw Data	Infeas Base	Infeas to EL	Infeas to LL
1004	2	3	4	5	9	10	11	12	16	17	18	19
1010	2	3	4	5	9	10	11	12	16	17	18	19
1015	2	3	4	5	9	10	11	12	16	17	18	19
1020	2	3	4	5	9	10	11	12	16	17	18	19
1028	2	3	4	5	9	10	11	12	16	17	18	19
1102	2	3	4	5	9	10	11	12	16	17	18	19
1105	2	3	4	5	9	10	11	12	16	17	18	19
1112	2	3	4	5	9	10	11	12	16	17	18	19
1119	2	3	4	5	9	10	11	12	16	17	18	19
1127	2	3	4	5	9	10	11	12	16	17	18	19
1200	2	3	4	5	9	10	11	12	16	17	18	19
1201	2	3	4	5	9	10	11	12	16	17	18	19
1212	2	3	4	5	9	10	11	12	16	17	18	19
1222	2	3	4	5	9	10	11	12	16	17	18	19
1225	2	3	4	5	9	10	11	12	16	17	18	19
1300	2	3	4	5	9	10	11	12	16	17	18	19
1304	2	3	4	5	9	10	11	12	16	17	18	19
1308	2	3	4	5	9	10	11	12	16	17	18	19
1314	2	3	4	5	9	10	11	12	16	17	18	19
1325	2	3	4	5	9	10	11	12	16	17	18	19

APPENDIX L
GANTT CHARTS-PHASE TWO EXPERIMENT
HIGH STOCHASTICITY

GANTT CHARTS
HIGH LEVEL OF STOCHASTICITY

	50% Partial Buffer Size				JG5 Partial Buffer Size				JG6 Partial Buffer Size			
Network Number	Raw Data	Infeas Base	Infeas to EL	Infeas to LL	Raw Data	Infeas Base	Infeas to EL	Infeas to LL	Raw Data	Infeas Base	Infeas to EL	Infeas to LL
1004	2	6	7	8	9	13	14	15	16	20	21	22
1010	2	6	7	8	9	13	14	15	16	20	21	22
1015	2	6	7	8	9	13	14	15	16	20	21	22
1020	2	6	7	8	9	13	14	15	16	20	21	22
1028	2	6	7	8	9	13	14	15	16	20	21	22
1102	2	6	7	8	9	13	14	15	16	20	21	22
1105	2	6	7	8	9	13	14	15	16	20	21	22
1112	2	6	7	8	9	13	14	15	16	20	21	22
1119	2	6	7	8	9	13	14	15	16	20	21	22
1127	2	6	7	8	9	13	14	15	16	20	21	22
1200	2	6	7	8	9	13	14	15	16	20	21	22
1201	2	6	7	8	9	13	14	15	16	20	21	22
1212	2	6	7	8	9	13	14	15	16	20	21	22
1222	2	6	7	8	9	13	14	15	16	20	21	22
1225	2	6	7	8	9	13	14	15	16	20	21	22
1300	2	6	7	8	9	13	14	15	16	20	21	22
1304	2	6	7	8	9	13	14	15	16	20	21	22
1308	2	6	7	8	9	13	14	15	16	20	21	22
1314	2	6	7	8	9	13	14	15	16	20	21	22
1325	2	6	7	8	9	13	14	15	16	20	21	22

APPENDIX M
DURATION METRIC CALCULATIONS - PHASE TWO EXPERIMENT

Phase Two – Low Stochasticity Duration Metric Results

	Low Stochasticity Level % Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1004	LL	EL	LL	EL	LL	EL	LL	EL	LL	EL
Infeasible to Modified	-20%	-11%	17%	30%	9%	22%	3%	15%	3%	15%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-20%	-11%	17%	30%	9%	22%	3%	15%	3%	15%
Network 1010										
Infeasible to Modified	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Network 1015										
Infeasible to Modified	-13%	-23%	36%	20%	26%	11%	0%	-12%	3%	-9%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-13%	-23%	36%	20%	26%	11%	0%	-12%	3%	-9%
Network 1020										
Infeasible to Modified	-10%	-15%	45%	17%	13%	6%	6%	0%	3%	-3%
Modified to Perfect Knowledge	-8%	0%	-21%	0%	-8%	0%	-8%	0%	-8%	0%
Infeasible to Perfect Knowledge	-18%	-15%	14%	17%	3%	6%	-3%	0%	-6%	-3%
Network 1028										
Infeasible to Modified	-19%	-17%	30%	30%	10%	13%	6%	9%	3%	6%
Modified to Perfect Knowledge	0%	0%	-3%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-19%	-17%	26%	30%	10%	13%	6%	9%	3%	6%

	Low Stochasticity Level % Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1102	LL	EL	LL	EL	LL	EL	LL	EL	LL	EL
Infeasible to Modified	-23%	-28%	67%	64%	4%	-3%	-1%	-8%	-5%	-12%
Modified to Perfect Knowledge	0%	0%	-1%	-6%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-23%	-28%	66%	53%	4%	-3%	-1%	-8%	-5%	-12%
Network 1105										
Infeasible to Modified	-18%	-24%	41%	41%	4%	-4%	-1%	-8%	-4%	-11%
Modified to Perfect Knowledge	0%	0%	0%	-7%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-18%	-24%	41%	30%	4%	-4%	-1%	-8%	-4%	-11%
Network 1112										
Infeasible to Modified	-20%	-27%	51%	39%	4%	-4%	-9%	-16%	-3%	-11%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-20%	-27%	51%	39%	4%	-4%	-9%	-16%	-3%	-11%
Network 1119										
Infeasible to Modified	-23%	-29%	61%	48%	2%	-6%	-2%	-10%	-5%	-12%
Modified to Perfect Knowledge	6%	0%	6%	0%	6%	0%	6%	0%	6%	0%
Infeasible to Perfect Knowledge	-18%	-29%	71%	48%	8%	-6%	4%	-10%	1%	-12%
Network 1127										
Infeasible to Modified	-22%	-23%	43%	40%	-1%	-2%	-5%	-6%	-6%	-7%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-22%	-23%	43%	40%	-1%	-2%	-5%	-6%	-6%	-7%

	Low Stochasticity Level									
	% Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1200	LL	EL	LL	EL	LL	EL	LL	EL	LL	EL
Infeasible to Modified	-13%	-13%	17%	17%	4%	4%	0%	0%	1%	1%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-13%	-13%	17%	17%	4%	4%	0%	0%	1%	1%
Network 1201										
Infeasible to Modified	-24%	-24%	46%	46%	4%	4%	6%	6%	0%	0%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-24%	-24%	46%	46%	4%	4%	6%	6%	0%	0%
Network 1212										
Infeasible to Modified	-29%	-16%	28%	52%	3%	23%	3%	23%	-6%	12%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-29%	-16%	28%	52%	3%	23%	3%	23%	-6%	12%
Network 1222										
Infeasible to Modified	-15%	-16%	23%	21%	14%	13%	0%	-2%	3%	2%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-15%	-16%	23%	21%	14%	13%	0%	-2%	3%	2%
Network 1225										
Infeasible to Modified	-10%	-20%	47%	30%	19%	6%	11%	-2%	9%	-3%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-10%	-20%	47%	30%	19%	6%	11%	-2%	9%	-3%

	Low Stochasticity Level									
	% Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1300	LL	EL	LL	EL	LL	EL	LL	EL	LL	EL
Infeasible to Modified	-28%	-22%	55%	58%	-3%	5%	-9%	-2%	-8%	-1%
Modified to Perfect Knowledge	0%	-3%	-3%	0%	0%	-3%	0%	-3%	0%	-3%
Infeasible to Perfect Knowledge	-28%	-24%	51%	58%	-3%	2%	-9%	-5%	-8%	-4%
Network 1304										
Infeasible to Modified	-24%	-18%	32%	41%	-3%	4%	-4%	3%	-6%	1%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-24%	-18%	32%	41%	-3%	4%	-4%	3%	-6%	1%
Network 1308										
Infeasible to Modified	-25%	-22%	42%	48%	-4%	1%	-8%	-4%	-8%	-4%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-25%	-22%	42%	48%	-4%	1%	-8%	-4%	-8%	-4%
Network 1314										
Infeasible to Modified	-26%	-23%	45%	52%	-3%	1%	-8%	-4%	-8%	-4%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-26%	-23%	45%	52%	-3%	1%	-8%	-4%	-8%	-4%
Network 1325										
Infeasible to Modified	-17%	-23%	40%	30%	3%	-4%	-6%	-13%	-3%	-10%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-17%	-23%	40%	30%	3%	-4%	-6%	-13%	-3%	-10%

Phase Two – High Stochasticity Duration Metric Results

	High Stochasticity Level % Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1004	LH	EH	LH	EH	LH	EH	LH	EH	LH	EH
Infeasible to Modified	-36%	-30%	155%	182%	4%	15%	-3%	7%	-3%	7%
Modified to Perfect Knowledge	-14%	0%	-14%	0%	-14%	0%	-14%	0%	-14%	0%
Infeasible to Perfect Knowledge	-45%	-30%	118%	182%	-11%	15%	-17%	7%	-17%	7%
Network 1010										
Infeasible to Modified	-54%	-22%	83%	167%	-17%	39%	-30%	19%	-27%	23%
Modified to Perfect Knowledge	0%	0%	-14%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-54%	-22%	58%	167%	-17%	39%	-30%	19%	-27%	23%
Network 1015										
Infeasible to Modified	-36%	-28%	79%	100%	4%	17%	-17%	-7%	-17%	-7%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-36%	-28%	79%	100%	4%	17%	-17%	-7%	-17%	-7%
Network 1020										
Infeasible to Modified	-28%	-18%	48%	57%	12%	27%	0%	14%	-3%	10%
Modified to Perfect Knowledge	-3%	0%	-10%	0%	-3%	0%	-3%	0%	-3%	0%
Infeasible to Perfect Knowledge	-30%	-18%	33%	57%	8%	27%	-3%	14%	-7%	10%
Network 1028										
Infeasible to Modified	-33%	-43%	200%	140%	17%	0%	4%	-11%	4%	-11%
Modified to Perfect Knowledge	0%	0%	-7%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-33%	-43%	180%	140%	17%	0%	4%	-11%	4%	-11%

	High Stochasticity Level % Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1102	LH	EH	LH	EH	LH	EH	LH	EH	LH	EH
Infeasible to Modified	-37%	-41%	256%	188%	14%	0%	-11%	-11%	-9%	-9%
Modified to Perfect Knowledge	0%	-5%	-12%	-4%	-11%	-10%	0%	-12%	0%	-12%
Infeasible to Perfect Knowledge	-37%	-44%	212%	176%	1%	-10%	-11%	-22%	-9%	-20%
Network 1105										
Infeasible to Modified	-33%	-43%	200%	148%	9%	-9%	-7%	-21%	-4%	-19%
Modified to Perfect Knowledge	0%	-3%	0%	0%	-1%	-3%	0%	-3%	0%	-3%
Infeasible to Perfect Knowledge	-33%	-45%	200%	148%	7%	-11%	-7%	-23%	-4%	-21%
Network 1112										
Infeasible to Modified	-35%	-37%	183%	157%	3%	0%	-15%	-21%	-13%	-18%
Modified to Perfect Knowledge	0%	-6%	-4%	-3%	0%	-6%	0%	-3%	0%	-3%
Infeasible to Perfect Knowledge	-35%	-41%	173%	150%	3%	-6%	-15%	-23%	-13%	-20%
Network 1119										
Infeasible to Modified	-32%	-38%	164%	148%	6%	-5%	-1%	-11%	-4%	-14%
Modified to Perfect Knowledge	-7%	0%	-5%	-2%	-7%	0%	-7%	0%	-7%	0%
Infeasible to Perfect Knowledge	-36%	-38%	152%	142%	-1%	-5%	-8%	-11%	-11%	-14%
Network 1127										
Infeasible to Modified	-37%	-42%	168%	154%	1%	-6%	-8%	-15%	-7%	-13%
Modified to Perfect Knowledge	0%	0%	-2%	-4%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-37%	-42%	162%	143%	1%	-6%	-8%	-15%	-7%	-13%

	High Stochasticity Level									
	% Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1200	LH	EH	LH	EH	LH	EH	LH	EH	LH	EH
Infeasible to Modified	-38%	-26%	61%	94%	-2%	19%	-7%	12%	-7%	12%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-38%	-26%	61%	94%	-2%	19%	-7%	12%	-7%	12%
Network 1201										
Infeasible to Modified	-28%	-37%	108%	81%	10%	-4%	8%	-6%	-5%	-18%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-28%	-37%	108%	81%	10%	-4%	8%	-6%	-5%	-18%
Network 1212										
Infeasible to Modified	-39%	-29%	67%	94%	10%	28%	-4%	12%	-10%	5%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-39%	-29%	67%	94%	10%	28%	-4%	12%	-10%	5%
Network 1222										
Infeasible to Modified	-31%	-36%	126%	109%	21%	12%	6%	-2%	8%	0%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-31%	-36%	126%	109%	21%	12%	6%	-2%	8%	0%
Network 1225										
Infeasible to Modified	-30%	-36%	104%	88%	26%	15%	7%	-2%	2%	-6%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-30%	-36%	104%	88%	26%	15%	7%	-2%	2%	-6%

	High Stochasticity Level									
	% Change in Duration									
	Pessimistic		Optimistic		50% Buffer		JG5 Buffer		JG6 Buffer	
Network 1300	LH	EH	LH	EH	LH	EH	LH	EH	LH	EH
Infeasible to Modified	-36%	-32%	109%	111%	-1%	6%	-12%	-6%	-10%	-4%
Modified to Perfect Knowledge	0%	0%	-5%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-36%	-32%	98%	111%	-1%	6%	-12%	-6%	-10%	-4%
Network 1304										
Infeasible to Modified	-31%	-31%	88%	90%	1%	4%	-5%	0%	-1%	4%
Modified to Perfect Knowledge	0%	0%	-4%	-5%	0%	-3%	0%	-5%	0%	-5%
Infeasible to Perfect Knowledge	-31%	-31%	80%	80%	1%	1%	-5%	-5%	-1%	-1%
Network 1308										
Infeasible to Modified	-41%	-34%	132%	162%	-9%	3%	-14%	-3%	-17%	-6%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-41%	-34%	132%	162%	-9%	3%	-14%	-3%	-17%	-6%
Network 1314										
Infeasible to Modified	-37%	-34%	120%	129%	-3%	1%	-10%	-7%	-10%	-7%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-37%	-34%	120%	129%	-3%	1%	-10%	-7%	-10%	-7%
Network 1325										
Infeasible to Modified	-30%	-39%	126%	98%	7%	-6%	-5%	-17%	-7%	-19%
Modified to Perfect Knowledge	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Infeasible to Perfect Knowledge	-30%	-39%	126%	98%	7%	-6%	-5%	-17%	-7%	-19%

APPENDIX N
STABILITY METRIC CALULATIONS - PHASE TWO EXPERIMENT

	Stability Metric Calculations **Phase Two Experiment** **Low Stochasticity Level** **Infeasible Baseline Schedule to Modified Baseline Schedule**				
Network	Pessimistic	Optimistic	50%	JG5	JG6
1000	74	74	75	75	76
1100	80	80	81	81	82
1200	86	86	87	87	88
1300	92	92	93	93	94

	Stability Metric Calculations **Phase Two Experiment** **Low Stochasticity Level** **Infeasible Baseline Schedule to Modified Baseline Schedule**				
Network	Pessimistic	Optimistic	50%	JG5	JG6
1000	77	77	78	780	79
1100	83	83	84	84	85
1200	89	89	90	90	91
1300	95	95	96	96	97

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