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Request Generation II
Mission Planning and Scheduling

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Request Generation II (ReGe II) is a PC-based prototype knowledge based system intended to assist USAF personnel in planning and scheduling satellite operations for their Mission Control Complexes (MCC). It aids MCC personnel in producing weekly Program Action Plans (PAPs) for each of the satellite vehicles an MCC is responsible for monitoring and maintaining. The PAPs are input to the Resource Control Complex (RCC) which schedules all satellite support requests for usage of the network.

ReGe II is an IR&D project that combines the concepts of two previous projects, Request Generation (ReGe I) and MCC Scheduling Automation (MSA). The aim of ReGe II is to assist USAF personnel by evolving the task of vehicle planning and scheduling away from manual and repetitive data sorting with the use of automation with the intent of freeing the PA up to place emphasis on the more important aspect of the task: understanding the changing needs of the US owned satellites. This is particularly important in the current environment where satellites are increasing in number and complexity and staff is frequently turning over due to job rotation.

The future intent is to imbed this planning and scheduling capability within the future CCS-2000 architecture. This will provide an automated function for populating the network with maintenance requests and will provide the connectivity between the MCC operators and the existing configuration controlled mainframe databases.

Satellite Support Planning Process

Monitoring the health and performing maintenance on the US owned satellites is a responsibility divided among a number of Mission Control Centers (MCC). Within each MCC, a staff of Planner Analysts (PAs) are responsible for understanding the needs of the vehicles which the MCC controls. On a weekly basis Program Action Plans (PAP) are produced which detail support requests for the network resources needed to monitor, command and control with each vehicle. The PA's are guided by three objectives when planning for vehicles:

- o Requests for support need to satisfy vehicle requirements documented by Tests Operation Instructions (TOIs), Test Operation Orders (TOOs) and Memograms.
- o Requests for resources should be combined where possible to reduce the burden on network resources.
- o Requests should be as flexible as possible, allowing the largest time window within which a support needs to be scheduled.

Currently the planning process begins with the PA sitting down with paper listings describing vehicle events such as acquisition of the vehicle, vehicle sun eclipses or sun-vehicle-earth angles.

Next, the PA reviews documents describing the vehicle requirements (TOIs, TOOs and memograms).

Particular attention must be paid to requirements which may have changed since the last time the PA did planning for that specific vehicle [Figure 1].

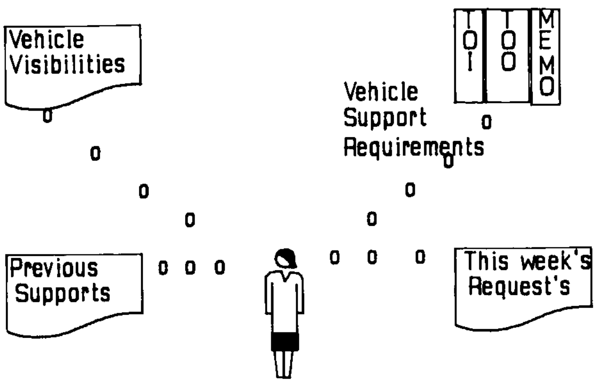

Figure 1:
Planner Analyst Tasks

The plan which the PAs develop to satisfy the vehicle requirements is recorded on paper and carried to a computer terminal, the data is entered into the system, and transferred to the Resource Control Center (RCC).

The RCC is responsible for scheduling the range resources based on the requests made by all MCCs. Conflicts are resolved via

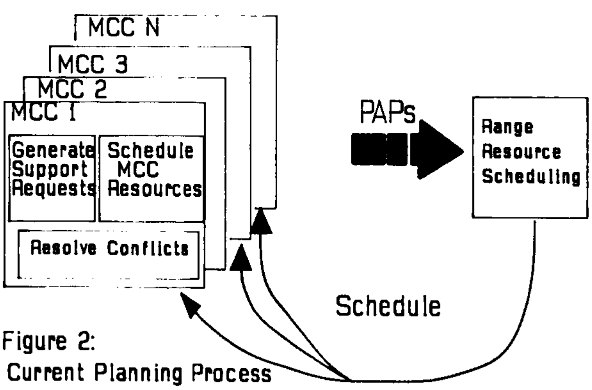

Figure 2:
Current Planning Process

phone calls to individual MCCs. Once the range schedule is conflict free, the schedule is published.

The MCC plans will be readjusted to the new schedule and the next phase of vehicle planning can begin [Figure 2]. Until recently, PA tasks were performed by civilians with extended experience. These tasks are now being transitioned to DoD military personnel. Development of tools which will assist in training, performing the job and in turnover due to rotation become very important in this environment.

Much of the work that has been done in this arena has focused on the scheduling task within the RCC. IBM's work began with research on scheduling tools for the RCC led by Dr. Mansur Arbabi. During that research period, IBM won the contract which developed the RCC scheduling software and is currently on contract to maintain it.

Research done on scheduling within the RCC branched into MCC scheduling. A series of projects followed, each building on the lessons learned from the previous

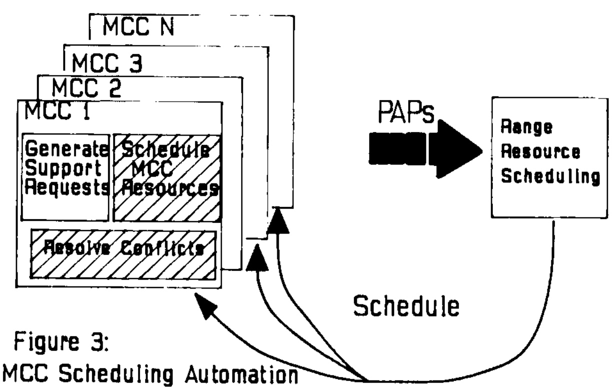

Figure 3:
MCC Scheduling Automation

project. The three projects were: MCC Scheduling Automation (MSA), Request Generation (ReGe) and ReGe II.

The MCC Scheduling Automation (MSA) research resulted in a prototype which simultaneously schedules all requests for an MCC for its resources for a specified week [Figure 3]. MCC resources considered by the algorithm include personnel and equipment such as control points, command and telemetery CSEGS, processor loading and mission unique equipment. This also includes range conflict checks. An interactive capability allows the operator to make request changes and re-generate the schedule.
The MSA project was done on the host using APL with the anticipation of interfacing with the configuration controlled databases. ReGe I took the next step in the research toward developing MCC scheduling tools for distributing the data and the processing to intelligent workstations [Figure 4].

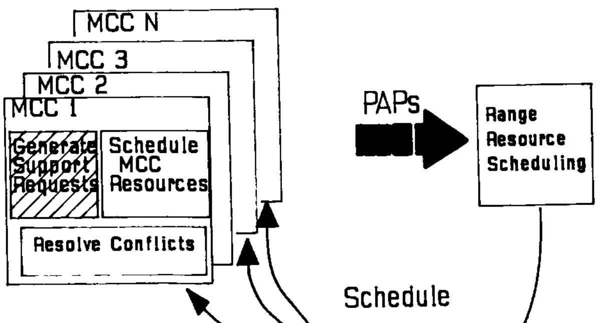

Figure 4:
Request Generation I

Request Generation (ReGe I) is the next generation MCC scheduling tool. It is a PC based prototype with a modular design which generates requests for a single vehicle per run [Figure 5]. With the lessons learned on scheduling algorithms and user interfaces behind this research, ReGe I focuses on another aspect of the problem, ´can the rules for scheduling different support or maintenance requirements be represented in a knowledge base?´ Our early prototyping in ReGe I indicates that the answer was ´yes´.

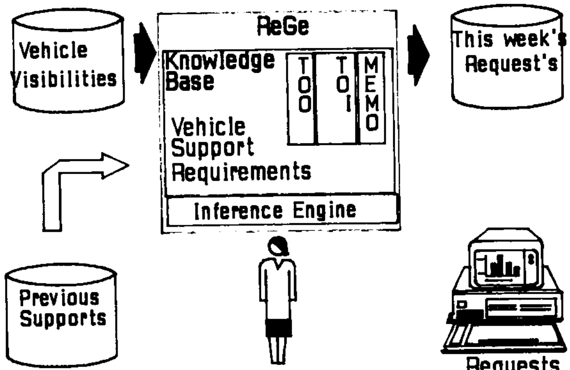

Figure 5:
ReGe Structure

ReGe II research redefines and builds on the objectives of MSA and ReGe II [Figure 6].

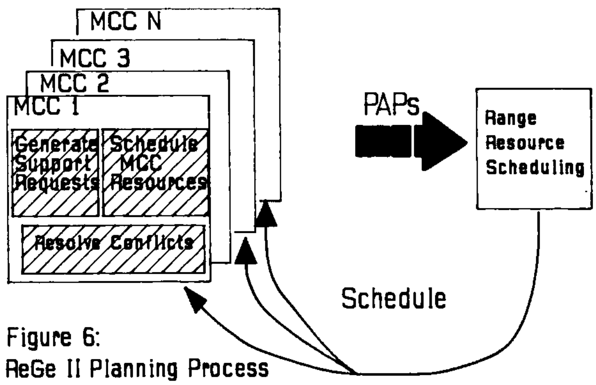

Figure 6:
ReGe II Planning Process

Objectives for ReGe II included providing a tool to generate vehicle support requests which would:

- o provide an interface to the planner analyst to
  - (a) define data to be used in the scheduling algorithm,
  - (b) initiate the algorithm and
  - (c) modify the results of the algorithm.
- o consider constraints such as vehicle events and MCC resources when applying the scheduling algorithm.
- o utilize vehicle definition and requirement definition when applying the scheduling algorithm.

The most challenging design issues of this work are the structure of the knowledge base and distribution of the interaction between the knowledge base and conventional code.

Processing schedules involving dates and numbers was found to be best performed by conventional code. Access to the data to be processed and the organization of that data was better represented at a higher level, using expert systems. The kind of data needed in the processing, thus what types of matching would be needed drove the design of the knowledge structure for vehicle definition, vehicle event definition, support requirement definition and support requests.

The greatest challenge in structuring the knowledge base for ReGe II was representing the vehicle requirements. Each requirement definition includes:

- o what event(s) drive the need for the requirement.
- o an indicator of the complexity of scheduling a requirement.
- o rules for combining requirements together.
- o which vehicles were defined as needing the requirement.

Driving events for a requirement would be one or a combination of the following: date specific, time specific, previous support(s), vehicle event(s). Again, vehicle events that a requirement might be dependent on might be acquisition or sun-vehicle-earth angles or eclipse information.

The complexity indicator of a support requirement must be reflective of the types of constraints which are on the requirement. The more constraints, the more difficult it is to schedule, the higher the complexity indicator should be. The complexity indicator is used in determining the order in which requests are generated.
Rules for combining requests for support are essential in meeting one of the primary goals of a planner analyst. That goal is to reduce the load on the satellite network resources by combining requirements and use of resources where possible into one request.

The algorithm employed by ReGe II begins by processing each requirement in priority order, for each vehicle defined as needing that requirement. A search or match is then done to find all of the events defined as triggering the need for the requirement. Once a requirement is determined to be needed for the current week, a search is then done for other support requests that this requirement can be combined with. The request is then either added to another request or generated as a new request. Lastly, resources are checked and if a conflict is identified, the request is marked as in conflict.

The user interface concepts of MSA for graphical representation of the vehicle events and the support requests and an interactivity were incorporated into ReGe II.

Beyond ReGe II, The next step is to develop a prototype of the tool for user feedback on: the HCI, the knowledge representation and the processing of the expert system and conventional code. The planner analyst needs to keep control of essential tasks and be freed from mundane, repetitive, data sorting task.

Summary

The research performed by IBM in the scheduling arena has resulted in insight and refinements to information representation, information processing and operator interaction.

IBM's research in MSA, ReGe I and II is aimed at assisting the planner analyst within the MCC by evolving the task away from manual and repetitive data sorting through automation in order to free them up for a more important emphasis: understanding the changing needs of the vehicle. In an environment where the staff is turning over frequently due to job rotation and where vehicles are increasing in number and complexity, tools which reshape the current planner analyst task are essential.

This research supports an approach which distributes data between existing configuration controlled mainframe databases to intelligent workstations in the MCCs which process data conventionally for computational operations, but represents and accesses it through the higher level representation using expert systems.

Arbabi, Mansur PHD., Garate, John A., Kocher,Donald F., "Interactive Realtime Scheduling and Control," PROCEEDINGS OF THE 1985 SIMULATION CONFERENCE, Chicago. Ill., Jul, 1985.

IBM-FSD, "Data System Modernization : System Scheduling," (AT-13), document no. C27-0020-13-01, Apr., 1980.

IBM-FSD, "Data System Modernization : Generic Range Scheduling Functional Analysis," (AT-13), contact no. F04690-81-C-003, Oct., 1982. 1980.

IBM-FSD, "Range Scheduling AAutomation," Report no. 2G59-IRAD, 1982.