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Matt Schnugg
University of Michigan

Patrick Ward
University of Michigan

Toby Zhang
University of Michigan

Zeeshan Syed
University of Michigan

Joseph Walls
University of Michigan

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Matt Schnugg
Ross School of Business
University of Michigan
mschnugg@umich.edu

Patrick Ward
Ross School of Business
University of Michigan
ptward@umich.edu

Toby Zhang
College of Engineering
University of Michigan
cczhang@umich.edu

Zeeshan Syed
College of Engineering
University of Michigan
zhs@umich.edu

Joseph Walls
Ross School of Business
University of Michigan
jgwalls@umich.edu

ABSTRACT

This paper describes a real world case of the application of the analytic hierarchy process (AHP), a multi-criterion decision making approach, to the allocation of thousands of software developers to over a hundred development projects. The approach attempts to balance the value of each project to the business with the resources applied to it. Significant cost savings are expected to result from this approach.

Keywords

Analytic Hierarchy Process, AHP, software development, IT project management, Project Portfolio Management, PPM

INTRODUCTION

The Server and Tools Business (STB) is a division of a large software company that licenses products and delivers services designed to help IT professionals become more productive and efficient. (Company Annual Report). STB has more than 10,000 employees and annual revenues of over $10B. These 10,000 employees are allocated among nearly 200 software development projects, 80% of which are engineering focused while the rest deal with marketing and other shared services. Each project is owned by one of four business units, denoted in this paper as Businesses A, B, C and D. The leadership team of STB analyzes each project's staffing and performance on an ongoing basis, and decides annually how to allocate resources among projects.

THE PROJECT

A team of students from the Tauber Institute for Global Operations at the University of Michigan, advised by an engineering professor and a business professor, worked with company management to develop a more flexible, lightweight, and repeatable process for assessing and optimizing STB's allocation of employees to projects. The team had seven objectives:

1. Increase the capabilities of and develop a governance model for a project monitoring database.
2. Implement a systematic method for scheduling project reviews.
3. Build a central tool to capture resources and assets mapped to key customer scenarios.
4. Design a model for the leadership team to use to optimize allocation of development resources to projects.
5. Document the resource allocation model and other key operational processes.
6. Design benchmarking reports to enable targeted resource reallocations.

7. Document team roles to enable management to identify opportunities for efficiency gains.

In achieving these objectives, the authors generated results estimated to generate annual efficiency gains of almost $1 million. This paper focuses on achieving the fourth of these objectives, where the team designed and won executive support for adopting a framework that systematically incorporates qualitative and quantitative assessments in assigning engineering project priorities and resources.

The situation faced by STB can be characterized as one of project portfolio management or PPM (De Reyck, Grushka-Cockayne, Lockett, Calderini, Moura and Sloper, 2005; Jeffery and Leviveld, 2004; LaBrosse, 2010). De Reyck et al distinguish between Project Management, Programme Management, and PPM:

> "Contrary to Project Management, which focuses on a single project, and Programme Management, which concerns the management of a set of projects that are related by sharing a common objective or client, PPM considers the entire portfolio of projects a company is engaged in, in order to make decisions in terms of which projects are to be given priority, and which projects are to be added to or removed from the portfolio."

Table 1 below, adapted from (Pennypacker and Dye, 2002), highlights the difference between PPM and multiple project management. The scope of the STB project is clearly at the PPM level: the question was how to prioritize among all projects within the business (for the purpose of reallocating developers if necessary); priorities were base on strategic goals; the review process was an annual one; and ultimate decisions were made by the president of STB.

	Project Portfolio Management	Multiple Project Management
Purpose	Project selection and prioritization	Resource allocation
Focus	Strategic	Tactical
Planning Emphasis	Long and medium term (annual/quarterly)	Short-term (day-to-day)
Responsibility	Executive/senior management	Project/resource managers

Table 1. High-level comparison of Project Portfolio Management and Multiple Project Management

An example of prior research relevant to this effort is De Reyck, et al (2005) who surveyed 125 companies (the majority of which were in the IT sector) to determine the extent to which PPM was being used to manage information technology (IT) projects. They found wide variation in the deployment of the elements of PPM, with 93% of the firms having a project inventory, but only half tracking the benefits of projects. Furthermore, they identified three stages of PPM: Stage I: portfolio inventory; Stage II: portfolio administration; and Stage III: portfolio optimization. Jeffery and Leliveld (2004)) identified similar stages research. Characteristics of the stages are highlighted in Table 2. At the time this research began, STB was in Stage II, and by the end of the project was beginning the move to Stage III.

Stage I	**Stage II**	**Stage III**
• Centralized project administration • Risk evaluation procedures • Explicit incorporation of resource constraints • Increasing business leaders' accountability for project results	• Project categorization • Evaluation of customer impact of the project portfolio results	• A project portfolio committee • Assessment of the financial worth of the portfolio • Management of project interdependencies • Tracking project benefits

Table 2. Processes Found at Various Stages of PPM

RESOURCE ALLOCATION OPTIMIZATION

A major part of the team's effort focused on developing tools that STB leadership could use to optimize the allocation of development resources to engineering projects. The tools developed by the team will help the STB leadership team make decisions like:

- Which projects should be prioritized for investment or disinvestment?
- How should management prepare to execute the resource allocation process?
- Which specific roles should be targeted when moving resources among R&D projects?

In the following we describe the current situation, the new process and how it was arrived at, and the results achieved by the team.

Current Situation

During the annual budgeting process, STB leadership must decide how many development resources (e.g., software engineers, testers, and program managers) to allocate to each of about one hundred and fifty engineering projects. This is a challenging exercise for two reasons: the difficulty of quantifying the expected "return" on the investment of a development resource in a project and the difficulty of determining whether a project is appropriately staffed given its scope.

Projects vary widely in the types of "returns" they generate. For example, a project within the Business A might generate no revenue directly but help drive programmers to contribute to the ecosystem of programs running on the companies platforms. On the other hand, a project within the Business B might have a direct link to an SQL product that management expects to generate revenue within one to two years. Projects may also generate strategic returns, such as enabling a key feature that competitors do not offer. The impossibility of comparing these outcomes using an "apples to apples" metric means there is inherent subjectivity in assessing relative project priorities.

Project staffing levels are tracked systematically in a project database. However, the leadership team has no easy way of assessing whether the staffing level of a given project is appropriate for its scope. Engineering data that would give a rough sense of project scale (e.g. lines of codes or number of modules) is not stored in the database. The leadership team's visibility into whether projects have too many or too few development resources to achieve quality and shipping targets is limited to business reviews and other meetings, where there are many topics to cover and there is a risk that project specific issues may not be addressed.

The authors devised a systematic process for resource allocation that addresses both of these challenges while being easy to manage with a limited time investment from the leadership team.

Analysis Process

We began with a diagnostic of the benefits and drawbacks of resource allocation methodologies used in prior years. This entailed obtaining materials used in past allocation exercises and interviewing selected individuals about each process and its outcomes. Through this research the team determined that four types of processes had been previously used (alone or in combinations) for resource allocation: investing or disinvesting in projects within a business based on the position of the business on a strategic framework (e.g., market attractiveness vs. projected business unit share); identifying projects with overlap or synergies through extended working sessions; balancing staffing ratios based on internal/external benchmarks; and voting on investment decisions by the executive team. These methodologies have certain benefits. With proper research and time investment, they can deliver a thorough analysis of project investment opportunities. However, the team's interviews identified a number of issues with the methodologies.

- Projects often can't be mapped to end markets, making assessments of market attractiveness and potential STB share impossible.
- Managing extended working sessions is exceedingly time-intensive.
- Project staffing needs and appropriate ratios vary based on project type or phase.
- Executive decisions or other "voting" methodologies may not systematically incorporate input from parties who have the most detailed knowledge of projects.

Understanding these issues led the team to define specific guidelines for potential alternative resource allocation methodologies to develop and propose to the leadership team.

- The methodology should be "systematically subjective." Because of the disparate qualitative and quantitative factors that make up a project's return, there is no practical way of determining a purely objective project ROI. However, the team's solution should systematically capture different subjective data points (e.g. strategic value and revenue growth potential) so that they are consistently evaluated and weighted in determining project "value".
- The methodology should not overburden management with analytic or administrative tasks. Leadership team members understand the importance of systematically allocating resources, but do not have time to do deep-dives into the current state and potential outcomes of 150 different projects. The solution should disaggregate the allocation process so the burden of managing it does not fall too heavily on any one set of individuals and should allow for the substitution of systematic managerial judgment for hard data when no hard data is readily available.
- The methodology should be transparent. Using methodologies that obscure the rationale for investment allocation decisions from people working closely with each project risks undermining confidence in the process and hurting morale throughout the businesses. The solution should incorporate input from business leaders with deep knowledge of each project and use that input consistently.

These guidelines rule out certain solutions. First, a "stage-gate" (Cooper, 1993) solution would not be practical because of the time investment and needed to prepare business plans for each Project and determine market viability. Second, pure project valuations (e.g., discounted cash flow models for projects) are not practical because some projects lack direct dollar payoffs, other project end-markets are poorly defined, and determining payoff potential in some growth businesses is highly subjective due to market uncertainty (e.g., cloud computing) .

The team identified two resource allocation techniques that would address the issues identified in the diagnostic phase: the Analytic Hierarchy Process (AHP) and market mechanism bidding.

AHP offers a way of systematically ranking a list of alternatives. The basic steps are to define a set of criteria along which alternatives are judged, weight those criteria through a series of pair-wise comparisons of importance, evaluate each alternative along each criteria, and finally score each alternative based on its performance on each criterion multiplied by that criterion's weight (Saaty, 2001). AHP has been applied to a wide variety of problems since its development. Vaidya and Kumar (2006) identified 150 different application papers that cited the use of AHP which they categorized into ten themes: selection, evaluation, benefit-cost, allocation, planning and development, priority and ranking, decision making, forecasting, medicine, and QFD (quality function deployment).

There are many examples of the use of AHP in an R&D context. For example, Liberatore (1987) combined AHP with cost-benefit analysis and integer programming to assist in resource allocation decisions in an industrial R&D environment. Meade and Presley (2002) applied the Analytical Network Process (a variant of AHP) to the decision of whether to develop a new high speed printing press for the printing industry, or upgrade their current offering. Jiang and Ruan (2010) combined AHP with a neural network to analyze fourteen high-tech projects in China. Lee and Kim (2000) combined AHP with goal programming to the problem of prioritizing six information systems projects.

The AHP approach has strong potential as a component of a solution for STB because it would allow for the systematic quantification of relative project performance along different dimensions. For example, for each business a project could be scored on its growth potential and strategic contributions without the explicit requirement of any quantitative data beyond its performance on those dimensions relative to other projects. Then, the project could be given an ultimate index score based on the relative importance of growth potential and strategy that the leadership team could use to compare its priority against that of other projects.

With market mechanism bidding, STB leaders are given a fixed number of "points" to bid on projects that are a proxy for the benefit or value of that project. Provided that the business leaders have clear instructions on what criteria they are to allocate their points on, and incentives to align their bids with the overall needs of the business, market mechanisms offer a way to disaggregate the project evaluation process to people with deep knowledge of them while preventing them from claiming every project is essential (due to the fixed amount of points).

The authors developed multiple models that incorporate both AHP and market mechanisms. They then refined these models based on feedback from management and ultimately merged them into one proposal that was presented to the head of STB, who approved the proposal. This model will be used to drive resource investment planning at upcoming STB leadership team meetings.

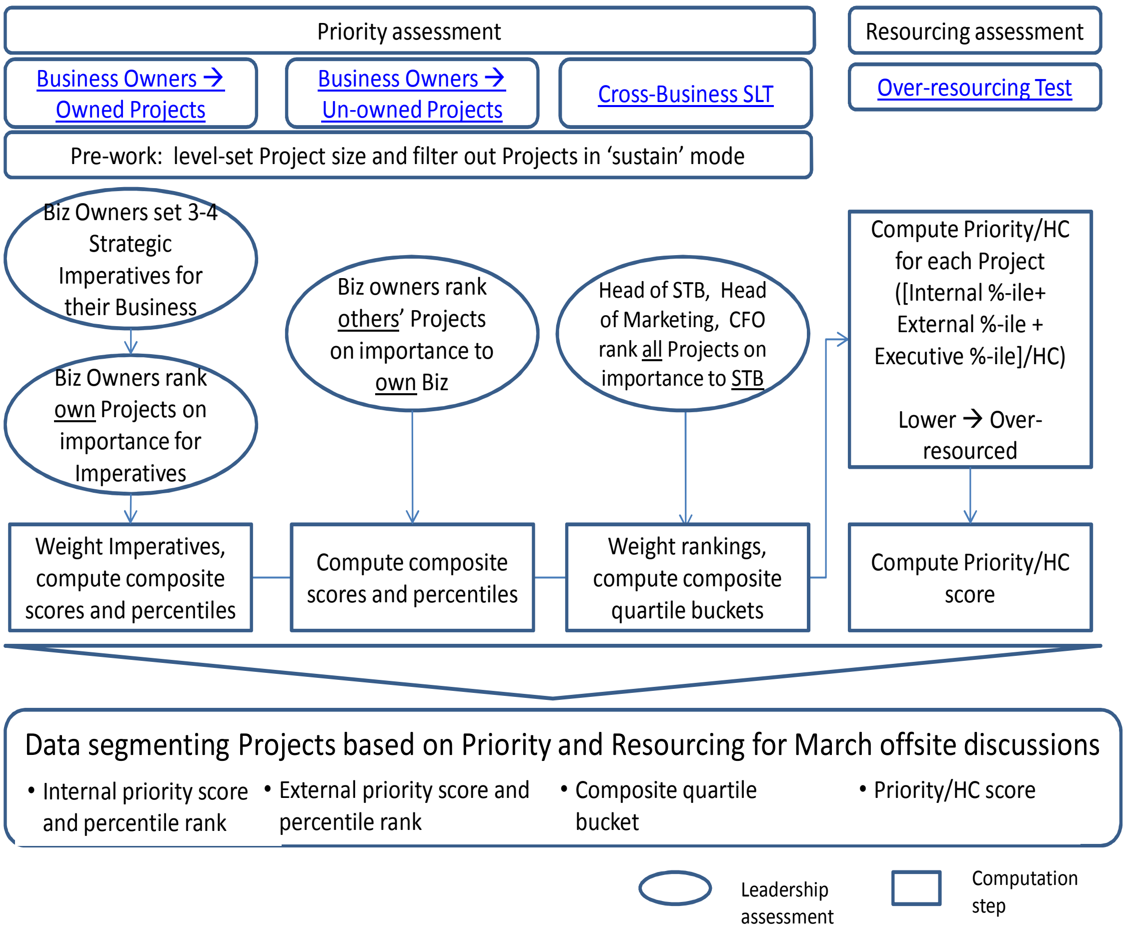

Figure 1. Model Overview

ASSESSMENT FRAMEWORK

The model uses three assessments of project priority and one assessment of project resourcing to build a robust dataset that enables the senior leadership team to make data-driven decisions on resource investments. See Figure 1.

Priority Assessment

The first assessment of project priority entails the owners of each of the four STB businesses prioritizing the engineering projects within their own businesses (i.e., Business Owners → Owned Projects Assessment). The output of this assessment is four separate ranked lists of projects by priority within each business. The assessment has three major steps:

- Criteria setting. Each business owner sets two to four strategic imperatives for the business for the year. These imperatives collectively are a comprehensive statement of the business' goals for the year. For example, they could include maximizing current revenue or developing a key strategic advantage over a competitor. Examples of strategic imperatives from FY10 are shown in Figure 2.

- Criteria weighting. Each business owner then uses pair-wise comparisons to systematically weight the relative importance of each strategic imperative. This process is demonstrated for the Business A in Figure 3.
- Owned project prioritization and scoring. For each strategic imperative, each business owner allocates a fixed number of points (e.g., 1000) across all of their projects based on the extent to which a project enables the business to deliver on each imperative. Following the point allocation, matrix multiplication is performed to combine the points each project receives for each criterion and the criterion weights to calculate a composite score for each project. The business owner then sorts projects by the composite score and calculates each project's percentile rank within the business. Figure 4 illustrates this process for Business A.

Business	Strategic Imperatives
Business A	• Support entire company platform
Business B	• Drive enterprise revenue • Engage breadth and web developers
Business C	• Drive revenue through X and Y • Manage & secure every client
Business D	• Continue share gains • Management, virtualization, and security

- Business Owners develop success criteria for each Project based on Strategic Imperatives
- For example, one for Business A could be 'Project contributes to driving enterprise revenue'
- Imperatives may need to become more specific to be effective in this role

Figure 2. Criteria Selection (Illustrative)

Business A		Strategic Imperatives (j)			
		SI 1	SI 2	SI 3	SI 4
Strategic Imperatives (i)	SI 1	1.00	0.25	0.33	3.00
	SI 2	4.00	1.00	3.00	7.00
	SI 3	3.00	0.33	1.00	3.00
	SI 4	0.33	0.14	0.33	1.00

1: Imperative i (row) and j (col.) equally important
3: Imperative i is weakly more important than j
5: Imperative i is strongly more important than j
7: Imperative i is very strongly more important than j
9: Imperative i is absolutely more important than j
Use reciprocals where column j dominates row I (e.g. 1/3)

Business A		Strategic Imperatives (j)			
		SI 1	SI 2	SI 3	SI 4
Strategic Imperatives (i)	SI 1	.12	.15	0.07	.21
	SI 2	.48	.58	.64	.5
	SI 3	.36	.19	.21	.21
	SI 4	.04	.08	.07	.07

Success Criteria (Strategic Imperatives)	Criteria weights
SI 1	14%
SI 2	55%
SI 3	25%
SI 4	7%

- Method of pair-wise comparisons (AHP), performed by each Business Owner
- Fill each shaded box based on importance of criteria i relative to j based on guidelines above
- Remainder of table is automatically populated with 1 or reciprocal

- Normalize table by dividing values in each cell by column total*

- Determine weights for each criterion by averaging normalized rows

* If comparisons are perfectly consistent, each column will be identical after normalizing. The final step of averaging across rows is to correct for inconsistencies in comparisons.

Figure 3 - Criteria Weighting - Business A (Illustrative)

Projects	Support Client	Support Server A	Support Server B	Support Mobile	Composite Scores	Percentile
Criteria weights →	14%	55%	25%	7%		
Programming Languages	117	111	37	159	96.8	76%
Advanced Test & Lab Mgmt Tools	72	74	119	32	82.0	53%
Architect Tools	72	56	179	79	89.9	69%
Business Application Tools	45	28	0	95	27.9	7%
Developer Engineering	54	56	75	63	60.9	38%
Developer User Education	99	102	22	111	82.5	46%
Developer User Experience	45	46	45	40	45.2	23%
International Product Experience	90	120	75	79	102.1	92%
Web Projects	63	93	149	79	101.7	84%
Online Dev Library	36	46	75	63	52.9	30%
Patterns & Practices	37	37	45	24	38.1	15%
Server	162	120	149	79	130.2	100%
Platform	108	111	30	95	89.7	61%
Total	1000	1000	1000	1000		

- For each Strategic Imperative, Business Owners allocate 1000 points across Projects within their Business based on Project importance for delivering on Imperative
- Calculate composite scores and percentile ranking based on points allocated and criteria weights

Figure 4. Business Owner → Owned Projects Priority assessment (Illustrative – Business A)

The second assessment of project priority entails the owners of each of the four STB businesses prioritizing the engineering projects strictly outside their business (i.e., those owned by the other three businesses) based on cross-business dependencies on each project (i.e., Business Owners → Unowned Projects Assessment). The output of this assessment is a single list of all of the projects within STB ranked by the total level of cross-business dependency. To execute this assessment each business owner allocates a fixed number of points (e.g., 10 x the number of projects outside their business) to projects outside their business, with projects they have the strongest dependencies receiving the most points. We illustrate this process in Figure 5. The total score for each project, its percentile rank, and position on the ultimate output list is based on the total points assigned to it by the three businesses that do not own it.

Points assigned by →	Business A	Business B	Business C	Business D	Total	Percentile
Programming Languages		30	20	130	180	98%
Advanced Test & Lab Mgmt Tools		60		50	110	95%
Architect Tools				50	50	77%
Business Application Tools		60			60	84%
Developer Engineering			10		10	32%
Developer User Education		50			50	77%
Developer User Experience		70			70	88%
Patterns & Practices		20			20	52%
Project 11		10		40	50	77%
Platform		30			30	60%
Project 1	0		60		60	84%
Project 2	17				17	49%
Project 3	17		35		52	81%
Project 4	17				17	49%
Project 5	0		65		65	88%
Project 6	86				86	91%
Project 7	86		15		101	93%
Project 8	9		30		39	73%
Project 9	0	30			30	60%
Project 10	43				43	76%

- Each Owner allocates 10 x (# of Projects outside their Business) to Projects outside their Business, based on Project importance to own Business (x-Business dependency)
- For example, Business A allocates 1120 points across 112 Projects outside Business A
- Calculate total score and percentile ranking based on points allocated

Figure 5. Business Owner → Un-owned Projects Priority Assessment (Illustrative)

The third assessment of project priority entails senior management of STB prioritizing all STB engineering projects based on their importance to STB's overall strategy (i.e., Cross-business Senior Leadership Team [SLT] Priority Assessment). To make this assessment less time-consuming, each individual senior manager would place each project in a quartile bucket (top = highest priority) rather than ranking them all. A project's total score from the cross-business SLT assessment is computed by weighting the quartile buckets assigned by each of the evaluators. We illustrate this process in Figure 6.

Project	CEO	CFO	Marketing	Composite Score	Percentile	Overall Quartile
Programming Languages	1	1	4	1.75	20%	Top
Advanced Test & Lab Mgmt Tools	2	2	4	2.5	48%	Second
Architect Tools	1	1	2	1.25	2%	Top
Business Application Tools	2	2	3	2.25	39%	Second
Developer Engineering	2	2	3	2.25	39%	Second
Developer User Education	1	1	2	1.25	2%	Top
Developer User Experience	3	4	1	2.75	60%	Third
International Product Experience	2	3	1	2	29%	Second
Project 1	2	3	1	2	29%	Second
Project 2	2	4	2	2.5	48%	Second
Project 3		4	2	1.5	8%	Top
Project 4	1	1	2	1.25	2%	Top
Project 5	2	1	3	2	29%	Second
Project 6	2	1	1	1.5	8%	Top
Project 7	1	3	2	1.75	20%	Top
Project 8	3	4	2	3	65%	Third
Project 9	2	2	4	2.5	48%	Second

- CEO, CFO, and Head of Marketing place each Project in quartile buckets based on importance for executing on overall STB strategy
- Calculate overall quartile by weighting individual assessments (e.g. CEO assessment at 50%, others at 25% each)

Figure 6 - Cross-Business SLT Priority assessment (Illustrative)

Resourcing Assessment

Because projects may not speed up, scale up, or improve in quality with incremental staff, the highest priority projects do not always need the most resources. To detect cases where project resourcing is misaligned with project priority, the model includes an over-resourcing test. This is a simple mathematical calculation based on the outcomes of the three priority assessments and staffing data from the project database. Managers of the resource allocation process calculate a resourcing score for each project as: ([Percentile in Business Owners → Owned Projects assessment] + [Percentile in Business Owners → Unowned Projects assessment] + [Percentile in Cross-Business SLT assessment])/Headcount Invested. This metric is lowest for projects that have high headcount and low assessed priority – indicating a misalignment between priority and resourcing. See Figure 7.

Project	HC	Internal Percentile	External Percentile	Executive Percentile	Resource Level
Project 1	97	18%	0%	35%	0.546391753
Project 2	18	9%	0%	5%	0.777777778
Project 3	25	0%	0%	25%	1
Project 4	207	25%	91%	92%	1.004830918
Project 5	211	95%	32%	100%	1.075829384
Project 6	109	28%	0%	92%	1.100917431
Project 7	35	15%	0%	25%	1.142857143
Project 8	77	0%	0%	92%	1.194805195
Project 9	144	53%	49%	71%	1.201388889
Project 10	4	0%	0%	5%	1.25
Project 11	194	55%	96%	92%	1.25257732
Project 12	167	37%	73%	100%	1.25748503
Project 13	123	63%	0%	92%	1.260162602
Project 14	191	92%	52%	98%	1.267015707
Project 15	95	26%	0%	98%	1.305263158
Project 16	34	0%	30%	16%	1.352941176

- Compute Resourcing metric by dividing the sum of percentile rankings for each priority assessment headcount by Project headcount and scaling
- Low metric value indicates low project priority relative to headcount – project may be over-resourced

Figure 7. Resourcing Assessment (Illustrative)

Model Outputs

To integrate the data from the four assessments and frame it in a manner that will help the senior leadership team make investment decisions, the model generates two key outputs. The first is illustrated in Figure 8. This chart uses the percentile rankings resulting from the Cross-Business SLT and Business Owner → Owned Projects Assessments to define a 2 x 2 matrix. Projects are plotted as bubbles on the matrix based on their rankings within those two priority assessments. Projects that fall into the lower left quadrant scored in the bottom half on both priority assessments, and conversely those in the upper right scored in the upper half on both priority assessments. The bubble size and color indicates the amount of "wiggle room" the management has to change that project's resourcing. Bubble size is based on the inverse of the results of the over-resourcing test, such that bigger bubbles have the most resources relative to their priority and represent projects that from which management could move more resources. Bubble color is based on the Business Owners → Unowned Projects Assessment, such that red projects have the lowest levels of cross-group dependency and are the "safest" to take resources from. Senior management's collective knowledge of specific projects should always inform decisions made on project resourcing. For example, if one were to interpret the chart naively, the easiest decision would be to move resources from the project corresponding to the largest red bubble on the lower left to the project corresponding to the smallest green bubble on the upper right. In other words, project rank does not dictate resources, but only highlights its priority. Nor is the measure of project resourcing absolute. Management must still look at these results in light of delivery deadlines and the current stage of the project before they make any final resource reallocations.

The second output is a dashboard with detailed data supporting the chart output. This is useful for sorting and bucketing projects based on specific assessments. A mockup of this dashboard is illustrated in Figure 9.

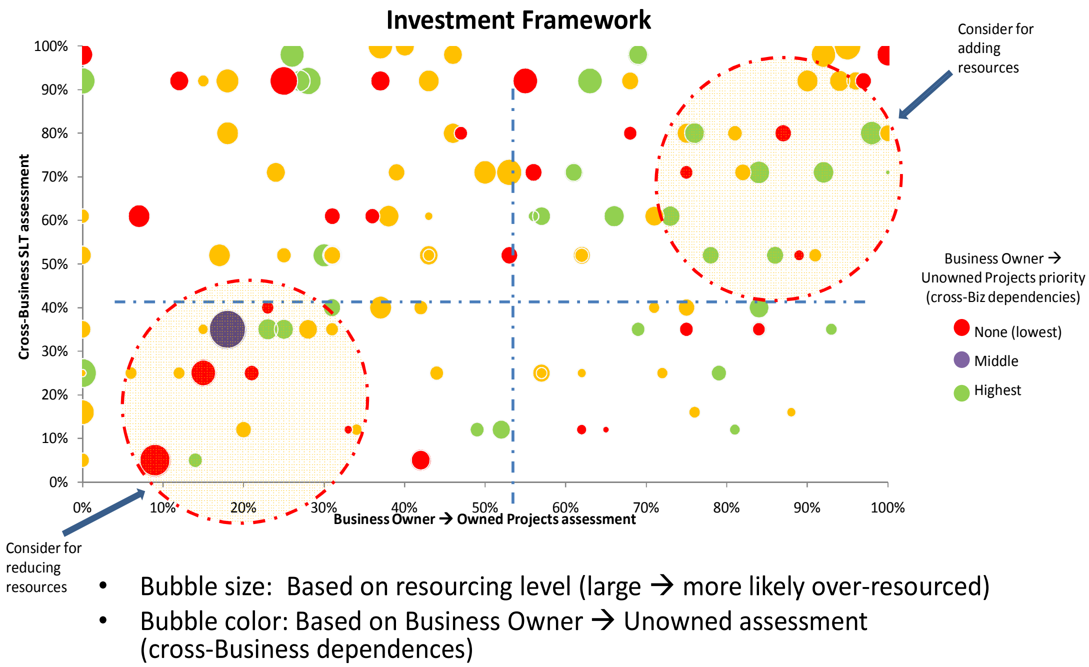

Figure 8 - Model output (Illustrative)

Bucket	Project	Business	Internal Priority Percentile Rank	External Priority Percentile Rank	Executive Priority Quartile	Resourcing Metric Score
Candidate to add resources (e.g. top 25% in all priority rankings and resourcing metric)	Project 3	Business A	98	76	Top	1.45
	Project 7	Business B	96	81	Top	1.52
	Project 12	Business C	80	93	Top	3.01
	Project 9	Business D	76	88	Top	2.29
"The Muddy Middle"	Project 1	Business A	60	74	2nd	.96
	Project 4	Business B	56	43	3rd	1.28
	Project 2	Business C	56	40	Top	1.38
	Project 14	Business D	40	68	4th	1.07
	Project 5	Business A	32	35	2nd	.81
Candidate to take resources (e.g. bottom 25% in all priority rankings and resourcing metric)	Project 6	Business B	20	24	4th	.61
	Project 11	Business C	18	8	4th	.64
	Project 10	Business D	16	19	3rd	.59
	Project 8	Business C	13	8	4th	.75
	Project 13	Business D	4	10	3rd	.61

Sortable dataset to use as guidance in resource investment decisions

Figure 9 - Supporting data the model generates

CONCLUSION

The model described above was presented to senior management of STB and it was approved for use at an upcoming offsite as the framework for discussions on headcount target setting for projects. We expect use of the model to generate over $600K in annual savings by reducing STB's annual hiring needs and associated on-boarding costs (signing bonuses and relocation). The model is designed to enable the management to optimize resource shifts from one project to another, rather than explicitly reduce staff, so one cannot directly link savings to it based on net headcount reduction. However, the model will generate savings by reducing unwanted staff attrition and thereby eliminating the on-boarding cost of new hires that would otherwise be necessary to fill those roles. This is because the model facilitates rotating top performers working on low priority projects to more rewarding, high priority projects. There is a high risk this talent would leave the company and need to be replaced with new hires if not for the reallocation decisions the model drives. Our estimate is based on typical unwanted attrition rates and on-boarding costs. (Of course, a high priority project may not be the most technically challenging and some developers may prefer technical challenge over being assigned to a project with high visibility. This consideration must be taken into account when assigning people to projects.)

Additionally, we expect implementation of the model to generate over $100K per year of value through time savings to senior executives. Based on discussions with management we anticipate the model will enable resource allocation decisions to require two fewer working days per year for each of member of senior leadership. The savings estimate is based on this time savings and estimated compensation and benefit requirements. Of course, saving executive management's time is far more valuable than the cost savings associated with salary saved, but it is difficult to quantify this benefit. Undoubtedly there are also revenue benefits resulting from having more executive time focused on the development of new products and markets in addition to benefits from managing the existing portfolio.

To fully appreciate the contribution of the results described here, it might be useful to look at it in the context of the evolution of STB's business over time. Historically, whenever what seemed to be a good idea came along, it was pursued. For all practical purposes, there were no constraints on funding for new projects because STB's business and its revenues were growing dramatically. As a result, there did not need to be a formal process of rebalancing the software development project portfolio. More recently, the business environment has become more competitive and the business has been required to more closely examine resource utilization. Over the last few years, different approaches for reviewing the portfolio have been tried but none has been deemed as satisfactory. Ultimately, decisions were based on the knowledge, experience, and attention of STB's president, with only unsystematic formal input from STB business managers. The process described here formally incorporates a wider set of perspectives into the now necessary priority setting process. Of course, bringing in not only the business manager's assessment of the importance of his own projects but the assessment of all managers of each other business unit's projects reduces the problem of everyone clamoring for support of their own "pet" projects. Giving the leadership team a say ensures that their knowledge and experience is incorporated into the priority setting process. So combining these three rankings is a critical part of making sure that all relevant stakeholders are brought into the process. Finally, although AHP is a commonly used tool for multi-criteria decision making as noted in a previous section of this paper, it is certainly new to STB and to managing the project portfolio of one of the world's largest software development organizations.

It is anticipated that the new priority setting process resulting from this effort will be undertaken at the end of each calendar year. Because of changing market conditions, new projects will arise, old projects will be phased out, and new priorities will need to be established. It is hoped that the new process will help STB to adapt to these changing conditions.

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REFERENCES

Company Annual Report.

Cooper, R. (1993). *Winning at New Products: Accelerating the Process from Idea to Launch*. 2nd Ed.,Cambridge, Mass: Addison-Wesley.

De Reyck, B., Grushka-Cockayne, Y., Lockett, M., Calderini, S., Moura, M., and Sloper, A. (2005) The Impact of Project Portfolio Management on Information Technology Projects, *International Journal of Project Management*, 23(2005) 524-537.

Jeffery, M. and Ingmar Leviveld, I. (2004) Best Practices in IT Portfolio Management, *Sloan Management Review*, Spring 2004, 41-49.

Jiang, H. and Ruan, J. (2010) Investment Risks Assessment on High-tech Projects Based on Analytic Hierarchy Process and BP Neural Network, *Journal of Networks*, Vol. 5., No. 4, April 2010, 393-402.

LaBrosse, M. (2010) Project Portfolio Management, *Employee Relations Today*, Summer 2010, 75-79.

Lee, J. and Kim, S. (2000) Using analytic network process and goal programming for interdependent information system project selection, *Computers & Operations Research*, 27(2000), 367-382.

Liberatore, M. (1987) An extension of the analytic hierarchy process for industrial R&D project selection and resource allocation, *IEEE Transactions on Engineering Management,* Vol. EM-34, No. 1, 12-18.

Meade, L. and Presley, A. (2002) R&D Project Selection Using ANP, *IEEE Transactions on Engineering Management*, Vol. 49, No. 1, Feb. 2002, 22-28.

Mustafa, M. and Al-Bahar, J. (1991) Project risk assessment using the analytic hierarchy process, *IEEE Transactions on Engineering Management*, Feb 1991, Volume: 38 Issue:1, 46 - 52.

Pennypacker, J. and Dye, L. (2002) Managing multiple projects: planning, scheduling, and allocating resources for competitive advantage*,* Marcel Decker, New York.

Ramanathan R. and Ganesh, L. (1995) Using AHP for resource allocation problems, *European Journal of Operational Research*, Volume 80, Issue 2, 19 January 1995, 410-417.

Saaty, T. (2001). *Fundamentals of Decision Making and Priority Theory*. Pittsburgh, Pennsylvania: RWS Publications.

Vaidya, O. and Kumar, S. (2006) Analytic hierarchy process: An Overview of Applications, *European Journal of Operational Research*, Volume 169, Issue 1, 16 February 2006, 1-29.