Smarter Campus: Catalyst for Research Collaboration through Optimal Assignment of Resources to Projects

Kirill (Carl) Osipov, IBM Software Group, osipov@us.ibm.com
Robin Lougee, IBM Research, rlougee@us.ibm.com
Anton Zorin, IBM Russia, az_personal@ru.ibm.com
Germán Goldszmidt, IBM Software Group, gsg@us.ibm.com
Vladislav Ponomarev, IBM Russia, vladislav.ponomarev@ru.ibm.com
Agenda

• Introductions
• Motivation
• Our Solution
• Conclusions
• Open Discussion
Agenda

• Introductions
• Motivation
• Our Solution
• Conclusions
• Open Discussion
Presenters

Dr. Robin Lougee
Research Staff Member
IBM Research

Carl Osipov
Software Architect
IBM Software Group

Anton Zorin
Software Engineer
IBM Russia

Vladislav Ponomarev
Software Engineer
IBM Russia
Co-authors

Dr. Germán Goldszmidt  
*Distinguished Engineer*  
IBM Software Group

Ilya Afanasiev  
*Software Engineer*  
IBM Russia
Acknowledgements

Dr. James Kraemer
Business Intelligence
Senior Consultant
IBM Research

Robert Friedlander
Business Intelligence
Senior Consultant
IBM Sales & Distribution
Why the name? Smarter Campus ⊆ Smarter Planet
Agenda

- Introductions
- Motivation
- Our Solution
- Conclusions
- Open Discussion
“I spent about 40% of my time chasing after funding, either directly (writing grant proposals) or indirectly (visiting companies, giving talks, building relationships)…These days, funding rates are abysmal: less than 10% for some NSF programs…I've had around 25 NSF proposals declined and only about 6 funded…So I can't let any potential source of funding slip past me.”

Matt Welsh
Associate Professor of Computer Science
Harvard University

Source: http://matt-welsh.blogspot.com/2010/05/secret-lives-of-professors.html
Secret Lives of Professors (con’t)

“My ‘professor anxieties,’ in order, are:
a) Making sure I have enough funding to support my students and staff;
b) Making sure I do well by my Ph.D. students in terms of helping them find good problems to work on.”

David Andersen
Assistant Professor of Computer Science
Carnegie Mellon University

Source: http://matt-welsh.blogspot.com/2010/05/secret-lives-of-professors.html
University Research Pain Points

1. Finding and pursuing research funding
   *excessive investment of time and labor*

2. Forming teams to pursue interdisciplinary proposals
   *isolated experts & students*

3. Finding and acquiring research resources
   *opaque processes & rules*

4. Collaborating across disciplines and organizations
   *fragmented view of a researcher*
Research Project Lifecycle

- Identify
- Acquire
- Measure
- Execute
- Publish
University Research **Pain Points** Relief

1. Finding and pursuing research funding
   *excessive investment of time and labor*
   - Use analytics to discover and recommend funding opportunities (e.g. grants)
   - Improve access to funding opportunities for junior faculty

2. Forming teams to pursue interdisciplinary proposals
   *isolated experts & students*
   - Recommend research projects to potential collaborators
   - Optimize assignment of people to projects

3. Finding and acquiring research resources
   *opaque processes & rules*
   - Enable self-service reservation of and access to research resources

4. Collaborating across disciplines and organizations
   *fragmented view of a researcher*
   - Use a portal platform for an aggregated, collaborative, social network based researcher profile
Agenda

• Introductions

• Motivation

• **Our Solution**
  • Overview
  • Personas & User Role Definitions
  • Research Lifecycle Scenario
  • Mathematical Optimization

• Conclusion

• Open Discussion
Agenda

• Introductions
• Motivation
• Our Solution
  • Overview
  • Personas & User Role Definitions
  • Research Lifecycle Scenario
  • Mathematical Optimization
• Conclusion
• Open Discussion
**Problem**

Help IBM university partners to improve utilization of university research resources

- Improve student experience though participation on research projects
- Provide faculty with more opportunities to participate on interdisciplinary research projects
  - Allocate other resources (e.g. labs, equipment) to the projects

**Solution**

Enable smarter decisions that optimize resources used by projects per university metrics, e.g.

- Alignment of student interests and project goals
- Improved staffing of projects with high impact on university reputation

Leverage unstructured (text based) data sources from faculty and students

- research publications
- web pages
- social network content
Research Project Lifecycle

- **Identify**
  - Discover, classify and organize information about research project candidate participants
    - e.g. principal investigators, students
  - potential research resources
    - e.g. sources of funding, students, equipment
  - Find and recommend funding opportunities for candidate researchers
  - Specify research resources for a research project
  - Identify project success metrics

- **Acquire**
  - Reserve and procure research resources
  - Staff research project with students

- **Execute & Publish**
  - Provide collaboration and social networking tools
    - e.g. meetings, wikis, groups

- **Measure**
  - Measure impact of research project on university reputation and researcher’s career
  - Collect bibliographic metrics on publications
  - Monitor change in research funding attracted by university year to year
  - Measure hours spent by students and post-docs on research projects
Agenda

• Introductions
• Motivation
• Our Solution
  • Overview
  • Personas & User Role Definitions
  • Research Lifecycle Scenario
  • Mathematical Optimization
• Conclusion
• Open Discussion
<table>
<thead>
<tr>
<th>Persona</th>
<th>Primary Role</th>
<th>Other Role(s)</th>
</tr>
</thead>
</table>
| vice president for research | • specify university research goals & priorities | research project portfolio owner, research capability development  
• monitor (i.e. via dashboards) university research project status, project details, funding brought to university by research projects  
• monitor dashboards on tenured vs. untenured faculty at university |
| associate dean | • review grant analyses prepared by grant analysts  
• assess potential impact of research projects on university reputation | faculty career advisor  
• identify potential research projects & principal investigators to pursue grants  
• assess potential impact of research projects on principal investigator career |
| grants analyst | • monitor alerts and notifications about upcoming grant reviews  
• specify maximum number of grant applications to be submitted by university researchers  
• identify and include in grant application suitable research grant co-sponsors  
• assess potential research project impact on university reputation | financial analyst  
• perform financial modeling & analysis of grant impact on university revenue  
• specify financial discounting to revenue from the grant |
| principal investigator | • learn about funding opportunities in area of research  
• apply for funding  
• identify research project collaborators  
• staff research projects  
• acquire research resources (e.g. tissue samples, HPC time)  
• publish research results | tenured faculty member, professor of medicine  
• mentor untenured faculty (e.g. advise on running research projects)  
• teach university courses |
| student | • write term and research papers  
• attend university courses  
• seek out research participation opportunities | research project participant  
• write reports with updates on progress/status  
• collaborate with students and researchers |
Agenda

• Introductions

• Motivation

• Our Solution
  • Overview
  • Personas & User Role Definitions
  • Research Lifecycle Scenario -- Demonstrate identify, acquire, and measure phases in a lifecycle of a research project focusing on analysis of a funding opportunity, grant recommendations, and resource reservation.
  • Mathematical Optimization

• Conclusion

• Open Discussion
Agenda

- Introductions
- Motivation
- Our Solution
  - Overview
  - Personas & User Role Definitions
  - Research Lifecycle Scenario
  - Mathematical Optimization
- Conclusion
- Open Discussion
Optimization: Recommend students to research projects

- generalized assignment problem
  - integer programming similar to the classic crew assignment problem

- objective function
  1. total sum of student project assignments weighted by student personal interests
  2. financial return on student assignments (?)
  3. qualitative factors of
     - reputation & good will
     - high importance research projects
Optimization problem (mixed int./binary programming)

- Maximize $v^Tx$ such that $Ax \leq b$, where
  - $x$ is a vector and $x_a$ is either
    - 1, if it is true that resource from $s_i$ is supplied to resource demanded by $d_j$
    - 0, otherwise
  - e.g. $s_i$ is a student and $d_j$ is a project proposal
- $v$ is a vector and $v_a$ is the value of $x_a = 1$,
  - e.g. $v_a$ = sum of
  - Quantity of funding for $d_j$
  - Quantified score of $d_j$ impact on university reputation
- $A$, $b$ represent constraints on $x_a = 1$, e.g.
  - $s_i$ can’t be supplied to more than 2 $d_j$, i.e. max. 2 projects per student
  - $s_i$ can’t spend more than 4 hours per $d_j$
Criteria: Annotate research proposals

- **Use text mining on**
  - proposal key phrases & terms
  - papers cited by proposal
  - prior journal articles by the proposing professor(s)

- **Produce research proposal metadata**
  - related keywords
  - mapping to student interests taxonomy
Criteria: Assess research proposal value

Criteria:

- Dollar value of the research contract(s)
- Professor age and tenure status
  - Increased weight for young, non tenured professors
- Quantity of external funding
  - E.g. from former students and friends of the university
- Potential to enhance the reputation of the university
Criteria: Determine student research area interest

Use text mining on

- externally visible writing
  - social networking websites
    - publicly expressed subjects, likes and dislikes
  - term & research papers
- university internal records
  - class room assignments
  - written Q&A with instructional staff
  - web based input from students
Agenda

• Introductions
• The Motivation
• Our Solution
• Conclusions
• Open Discussion
Conclusions

• **Tonkawa**
  • Incubation project
  • Completed preliminary proof-of-concept
  • Enables staffing recommendations based on social networking, optimization, and text analytics
  • Enables university partnership opportunities around “Smarter Campus”
Agenda

- Introductions
- The Motivation
- Our Solution
- Conclusions

- Open Discussion – Questions? Comments?
Thank You

- Hindi: धन्यवाद
- Traditional Chinese: 多謝
- Thai: ขอบคุณ
- Russian: Спасибо
- Spanish: Gracias
- English: Thank You
- French: Merci
- Brazilian Portuguese: Obrigado
- Italian: Grazie
- Simplified Chinese: 多谢
- Arabic: شكراً
- Japanese: ありがとうございました
- German: Danke
- Tamil: இல்லம்
- Korean: 감사합니다
Backup Slides
Why team with IBM?

**Both sides have distinct strengths**
- You know the university research process pain points better than anyone and have focused expertise.
- IBM brings leading technology, deep industry knowledge and global reach.

**IBM can deliver unique value**
- Proven IT capabilities
  - hardware infrastructure
  - systems management
  - software development
- Client references on business-critical, 24x7 readiness
  - Global Fortune 500 companies
  - Olympics / real-time systems
  - Disaster recovery, earthquake readiness
- Proven software products and solutions
  - Collaboration
  - Text mining
  - Optimization
- World-class world-wide research institute
  - IBM T. J. Watson Research Center
  - 3 in US, China, Haifa, India, Tokyo, Zurich