University Research Program (URP) Overview

- Only Cisco program that funds basic network research
  Complements Business Unites and other applied research efforts
  No IP claims. All awards are “unrestricted gifts”
- Funds research in topics relevant to Cisco technology interests
  Assured by engineering participation as proposal champions and reviewers
- Global scope and participation
  Top tier research universities well represented
  “Word of mouth”, reputation-enhanced, participation by who’s who
- Technology Group/BU engineers participate in award decisions
  Broad representation of volunteers from Cisco engineering assess research quality, relevance, and merit
- Impact on product development efforts
  Has led to research on product concepts/validation of ideas, influenced IETF work
# URP Awards by Topic CY1999 – 2005

<table>
<thead>
<tr>
<th>Topic Area</th>
<th>99</th>
<th>00</th>
<th>01</th>
<th>02</th>
<th>03</th>
<th>04</th>
<th>05</th>
<th>Total</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement &amp; Analysis</td>
<td></td>
<td></td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td></td>
<td>22</td>
<td>11%</td>
</tr>
<tr>
<td>Network Management</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td></td>
<td></td>
<td>4</td>
<td>19</td>
<td>9%</td>
</tr>
<tr>
<td><strong>Optical (transport, control plane, media)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocols (QOS, Multicast, BGP, etc)</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td></td>
<td>30</td>
<td>15%</td>
</tr>
<tr>
<td>Routing &amp; Switching</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>15</td>
<td>9</td>
<td>4</td>
<td></td>
<td>48</td>
<td>24%</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td></td>
<td>22</td>
<td>11%</td>
</tr>
<tr>
<td>Simulation &amp; Modeling</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>10</td>
<td>5%</td>
</tr>
<tr>
<td>Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td>Wireless &amp; Mobility</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td></td>
<td>23</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>11</td>
<td>11</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>38</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Total grants</strong></td>
<td>3</td>
<td>33</td>
<td>38</td>
<td>36</td>
<td>30</td>
<td>37</td>
<td>24</td>
<td>201</td>
<td>100%</td>
</tr>
</tbody>
</table>
Engineering Participation in URP Processes

- BU engineer acts as a Cisco Champion
  
  Technical liaison to PI (Principal investigator = researchers), briefs reviewers, internally champions research & results

  Ensures proposal reflects BU interests

  Many researchers value this relationship more than the award money!

- BU engineers assess merits of every proposal

  Review process utilizes a Cisco-wide database of >240 subject matter experts—all volunteers

  Assign at least 6 reviewers per proposal
URP Example: IP SLA Research

- “IP SLA: Traffic and Performance Measurement using Active Probing Techniques”

- The objective of the research is two-fold:
  1) to gain a better understanding of the applicability of active probing for Internet traffic and performance measurement; and
  2) to use this understanding to guide us in the design and development of sound and efficient probing techniques that have direct practical utility.
## URP Example: IP SLA Research

<table>
<thead>
<tr>
<th></th>
<th>Packet Loss</th>
<th>Delay</th>
<th>Jitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>State of the art</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modeling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results Presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CARD Program Overview

CARD (Cisco Applied Research & Development) Mission

Provide funding for short term (15-24 month horizon) research and development activities at selected universities leading to product enhancements, prototypes, or concepts that can be productized or contribute to future products

CARD Goals

- Leverage academic resources for collaboration to deliver technologies for use in Cisco product and services
- Accelerate R&D for product timelines on interesting technologies
- Streamline IP and contractual process

CARD Budget

$300K/qtr

Funded projects

CY03: 4, CY04: 6, CY05: 9, CY06: 4 (7 more in statement of work (SOW) definition or contract development phase)
CARD and Intellectual Property (IP)

- Projects are typically sponsored research efforts requiring coordination between principal investigator (PI), software developer, and legal entities
  - 2-4 months from conception to execution
  - IP strategy is critical internal discussion
  - Usual suspects: Publishing, IP rights & licensing, patent prosecution

- Contract philosophy
  - New IP developed under Cisco sponsored research project is made possible by university effort & Cisco $$/expertise but **ownership is transferred solely to the University**
  - In return for sole ownership University pays all patent prosecution costs and **provides Cisco a royalty free, non-exclusive license**
  - If university chooses not to prosecute patent for IP developed under Cisco sponsorship, **University grants Cisco right to patent and provide royalty free, perpetual, exclusive license to the technology**
CARD Operating Principles

- CARD cost-sharing model seeks to overcome risk of academic engagement
- BU provides technical leadership
- Technical Lead acts as primary interface to PI
- ARTI (Academic Research and Technology Initiatives) provides process management, advice, and contractual and financial management to BU
- ARTI negotiates contract based upon BU IP strategy
- Direct connection between academic investments and product development
- Increasing focus on “flipping” successful URP projects
CARD Examples: Sampled NetFlow Accuracy

- Objective: What is the accuracy of sampled NetFlow?

- Projects Volume Estimation for the Generation of Accounting Data with Sampling (VEGAS)
  3 years research project
  Modeling
  Getting some ISP traces
  Validation
  Results publication
CARD Examples: Sampled NetFlow Accuracy

- Higher accuracy for flows with
  - Many packets
    - Flow proportion is high
    - Observe longer (and characteristics remain)
  - Large packet size mean
  - Small packet size variation

\[
\text{StdErr}_{\text{rel}}[\hat{\text{Sum}}_f] = \frac{\text{StdErr}_{\text{abs}}[\hat{\text{Sum}}_f]}{\text{Sum}_f} = \sqrt{\frac{N^2}{n} \cdot \left( \frac{\sigma_{xf}^2 \cdot P_f + \mu_{xf}^2 \cdot (P_f - P_f^2)}{N_f \cdot \mu_{xf}} \right)}
\]