Session 4: The place of networking in curriculums

Moderator: Jim Kurose
University of Massachusetts Amherst

Session goals:

- learn about ongoing ACM/IEEE CS2013 curriculum efforts
  - CS2001/CS2013 overview
  - “net-centric computing”
- discuss updates/changes to current (2001) curricular recommendations in networking
- identify Sigcomm activities re: CS2013 for Fall 2011
Background: CS2013

- joint IEEE-CS, ACM joint task force sets curricular guidelines for undergrad programs in CS
  - http://cs2013.org
  - international
- every ~10 years, most recent: 2001 (update 2008)
  - 2013 guidelines now being formulated
- our (Sigcomm’s) knowledge area (KA): net-centric computing (likely to be renamed)
  - revised draft networking KA by end of 2011
- our help is welcome (and needed!) in formulating core and elective topics
  - now is the time to do something!

CC2001 Knowledge Areas

<table>
<thead>
<tr>
<th>Min # hours</th>
<th>Knowledge Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>Discrete Structures (DS)</td>
</tr>
<tr>
<td>38</td>
<td>Programming Fundamentals (PF)</td>
</tr>
<tr>
<td>31</td>
<td>Algorithms and Complexity (AL)</td>
</tr>
<tr>
<td>36</td>
<td>Architecture and Organization (AR)</td>
</tr>
<tr>
<td>18</td>
<td>Operating Systems (OS)</td>
</tr>
<tr>
<td>15</td>
<td>Net-Centric Computing (NC)</td>
</tr>
<tr>
<td>21</td>
<td>Programming Languages (PL)</td>
</tr>
<tr>
<td>8</td>
<td>Human-Computer Interaction (HC)</td>
</tr>
<tr>
<td>3</td>
<td>Graphics and Visual Computing (GV)</td>
</tr>
<tr>
<td>10</td>
<td>Intelligent Systems (IS)</td>
</tr>
<tr>
<td>10</td>
<td>Information Management (IM)</td>
</tr>
<tr>
<td>16</td>
<td>Social and Professional Issues (SP)</td>
</tr>
<tr>
<td>31</td>
<td>Software Engineering (SE)</td>
</tr>
<tr>
<td>0</td>
<td>Computational Science and Numerical Methods (CN)</td>
</tr>
</tbody>
</table>
CC2001: the “core”

- those units required of all students in all computer science degree programs
- not a complete curriculum
- must be supplemented by additional material
- not necessarily taken in intro courses, early in UG curriculum

“audience” for CS20**: broad set of students in wide range of colleges and universities

Theory versus practice (CS)

The ACM/IEEE view of Computer Science
Theory versus practice (CE)

The ACM/IEEE view of Computer Engineering

NC KAs: related KAs for 2013

- operating systems (15 hours)
- parallel and distributed computing (4 hours)
- systems fundamentals (30 hours)
  - computational paradigms, parallelism, cross-layer communications, state and state transition, resource allocation and scheduling
- information assurance and security (8 hours)
  - much of which was in net-centric computing in CS2001/2008
Thinking about the NC KA

- networking and communication: 10 core hours, plus 5 more core hours in security
  - core: loosely, what all UG CS majors should know
  - elective: for those desiring more depth, breadth
  - arguing for more hours won’t get us anywhere
- CS2013 desire: smaller core, “small footprint” curriculum
  - “promote flexible curricula models, without losing essence of rigorous CS education”
  - 2001 curriculum smaller than 1991, 2013 to be smaller than 2001
  - < 1/3 semester course

NC: current status (handout)

- NC. Net Centric Computing (possible rename: Networking and Communications) (10 core hours)
  - NC/Introduction [3 core]
  - NC/NetworkCommunication [7 core; elective]
  - NC/WebOrganization [elective]
  - NC/NetworkedApplications [elective]
  - NC/NetworkManagement [elective]
  - NC/NetworkInterfaceArchitecture [elective]
  - NC/MobileComputing [elective]
NC Introduction (3 hours)

**Topics:**
- background, history of networking, Internet
- network architectures
- range of specializations within net-centric computing
- networks and protocols
- networked multimedia systems
- client/server and Peer to Peer paradigms
- mobile and wireless computing
- multimedia servers and file systems (removed 2008)
- storage standards (Magneto Optical disk, CD-ROM, DVD) (removed 2008)

**Learning Outcomes:**
- Discuss evolution of early networks and Internet.
- Demonstrate ability to use common networked applications including e-mail, telnet, FTP, wikis, and web browsers, online web courses, and instant messaging.
- Explain hierarchical, layered structure of typical network architecture.
- Describe emerging technologies in net-centric computing, assess their current capabilities, limitations, and near-term potential.

NC/ Network communication (7 hours)

**Topics:**
- network standards, standardization bodies
- ISO 7-layer reference model, instantiation in TCP/IP
- overview of Physical and Data Link layer concepts (framing, error control, flow control, protocols)
- data Link layer access control concepts
- internetworking and routing (routing algorithms, internetworking protocols, congestion control)
- transport layer services (connection establishment, performance issues, flow and error control)

**Learning Outcomes:**
- Discuss important network standards in their historical context.
- Describe responsibilities of first (lowest) four layers of ISO reference model.
- Explain how a network can detect and correct transmission errors.
- Explain how a packet is routed over the Internet.
- Install a simple network with two clients and a single server using standard host configuration software tools such as DHCP.
Breakout discussion notes

**Marwan**
- Identify what separates networking from other disciplines – scale, decentralized
- Series of problems – layering/abstraction, reliability, resource sharing, addressing, routing/forwarding
- Devote time in core to wireless/mobility (fixed model is being broken)
- Why not just HOW
- Learning outcome: day in the life of a packet (e.g., web request)
- What are the tradeoffs
- Architectural principles: smart edge, end-end

**Jay**
- Naming/addressing, translation (DNS)
- Introducing network of networks concept (how are players, who pays….) get a grip on reality. Economics, social aspect
- How is internet different from other networks (what are/were alternatives)
- Packet switching v circuit switching
- TCP
- Multiplexing and resource allocations
- Internetworking and routing
- Christos – BGP and why we have that (policy)
- CDN and content providers – why
- X-ities. Teach students early on. Scale
- End-end principle versus smarts IN the core
- http
- Learning outcomes: how is Internet different from older nets; security (secure content v secure path). Principles and mechanics

---

**Olivier**
- Name different components (LAN, router, switch, link)
- Bottom up – links, framing, error control, multiple access, switching and forwarding (PC v CS)
- Routing – static. Key principle is aggregation (layer 2 v layer 3)
- DNS, naming/translation
- Socket API
- Congestion (optional – not core)
- Learning outcome: day in the life of a web request
What can we do?

- suggest “Sigcomm-blessed” KAs and learning outcomes
  - 10 core hours
  - electives
  - working with AC/IEEE task force (who welcome our input)
- provide input, commentary on closely related KAs
  - networking aspects appropriate?

What else can we do?

- model networking curriculum recommendation (informal, informational)
  - 2002 Sigcomm education workshop: “What would we be deeply embarrassed by, if our students did not know?”
    http://www-net.cs.umass.edu/sigcomm/education/workshop1.html
- "NSF/IEEE-TCPP curriculum initiative on parallel and distributed computing - core topics for undergrads
  - http://www.cs.gsu.edu/~tcpp/curriculum/
What can we do today?

- discussion of NC core
  - what’s missing?
  - what’s “extraneous” given 10-hour limit?
- discuss fall 2011 activity, after that, it’s too late
  - core
  - electives
  - related KAs
- on beyond CS2013
  - graduate, lab courses
  - reference
  - best practice