IERG5090 Advanced Networking Protocols and Systems

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Philosophy of this course

- A graduate level network course
  - Exposure to more advanced topics, useful for research in networking and related areas
  - Practical knowledge useful for working in industry
- Course content
  - Review some basic networking knowledge
  - Appreciate core design (or architecture) issues, design tradeoffs, some issues are not necessarily technical
  - Appreciate advanced technology, and latest trends

Assessment

- Exam 40%
- Homework and Labs 30%
  - SDN Lab based on Mininet
  - Hands-on Exercises with Emerging Protocols & Services, e.g.
    - IPv6 transitioning tools, SIP-based Multimedia services
- Project 30%
  - Propose Topic by early Feb
  - Midterm report by mid March
  - Final presentation and written report in mid April

Course outline

- Course website

  http://course.ie.cuhk.edu.hk/~ierg5090/

- Blackboard E-learning platform for discussions and Q&A

  http://www.cuhk.edu.hk/elearning

Week	Date	Topic	Instructor
1	9-Jan	Course Administration; Overview of course material	WCL, DMC
1	12-Jan	Internet architecture, service model, relationships with other networks	DMC
2	16-Jan	Internet routing - Single domain	DMC
2	19-Jan	Internet routing - Single domain	DMC
3	23-Jan	Internet routing - Interdomain, BGP	DMC
3	26-Jan	ISP Peering and policy based routing and configuration	DMC
4	29-Jan	[[[[[[Chinese New Year]]]]]]	
4	2-Feb	Control vs Forwarding planes, MPLS and traffic engineering	WCL
5	6-Feb	Netflow	WCL
5	9-Feb	Router internals, forwarding plane mechanisms	WCL
6	13-Feb	High speed switching/router fabric architectures	WCL
6	16-Feb	Software Defined Networking	WCL
7	20-Feb	Network Virtualization	WCL
7	23-Feb	Case studies of SDN, applications in Data Center and private WAN	DMC
8	27-Feb	TCP and congestion control	DMC
8	2-Mar	Network resource allocation, models	DMC
9	6-Mar	Network economics, network neutrality	DMC
9	9-Mar	Multimedia network services and protocols	WCL
10	13-Mar	SIP and the Internet Multimedia Subsystem of Cellular Networks	WCL
10	16-Mar	Video streaming, Adaptive streaming, DASH	WCL
11	20-Mar	Supporting the Real time Web: HTTP2.0/SPDY, Websocket and WebRTC	WCL
11	23-Mar	IPv4 vs IPv6, NAT as a solution	WCL
12	27-Mar	IPv6 transition	WCL
12	30-Mar	Protocol Architecture for Internet of Things (time-permitting)	WCL
13	3-Apr	IP Multicast and Content Distribution Networks	DMC
13	6-Apr	P2P networks for content distribution	DMC
14	10-Apr	Future Internet architecture proposals	DMC
14	13-Apr	Project presentations	WCL, DMC
15	20-Apr	Project presentations	WCL, DMC

Projects

- Pick a topic (welcome to discuss with us)
- Read classic and latest papers
- Try to carry out some research (small step ok):
  - Give a critique of existing system, and propose some alternative directions
  - Propose a new algorithm, protocol, to address some known problem
  - Measure/analyze some existing system, or proposed solution

Teaching expectations

- Student / Faculty expectation on teaching

  http://mobitec.ie.cuhk.edu.hk/StaffStudentExpectations.pdf

- Academic Honesty

  http://www.cuhk.edu.hk/policy/academichonesty

Internet evolution

Original design philosophy and how it is evolving

Key architectural ideas of Internet

- Internet is a complex system
  - Many different requirements
  - There is no unique way for its design
  - Architecture: high level design principles
- Some key ideas:
  - Packet switching, more suitable for elastic service
  - Layering, more flexible for evolution
  - Distributed operation, more robust, easier to scale by interconnecting autonomous systems
  - End-to-end principle, global address, dump pipes, and intelligence at end nodes

Internet evolution

- Some things are easier to evolve
  - Plug in new physical and data link layers, e.g. optical and wireless networking
  - Build Bigger and Faster Switches and Routers
  - Provide Scalable Networking Monitoring/ Measurement Capabilities
  - Perform Traffic Engineering & Enforce Resource Management Policy within a Single Administrative Domain
  - Develop overlays

Internet evolution (cont'd)

- Some things are harder to evolve
  - Perform Traffic Engineering & Enforce Resource Management Policy across Multiple Administration Domains
  - IPv4 to IPv6, especially for co-existence and transition
  - Add Quality of Service, Multicast, Security to support new application demands
  - Mixing Multimedia services within a session ; Enable Rapid Introduction of new Multimedia services
  - Support Interworking and Service Integration with legacy Networks/Services, e.g. PSTN and Cellular Networks
  - Compatibility with Implementation-Specific (non-standardized) Behavior of "Middle-boxes", e.g., NATs, Proxies, Load-Balancers
  - Evolving from the support of Man-to-Man or Man-to-Machine communication services, to Machine-to-Machine (Internet of Things) services

What drives evolution

- Many new applications
  - The applications service businesses are bigger than the network infrastructure service business
  - These applications (e.g. from Google, Facebook, Alibaba, Tencent etc) require tight integration with computation, quality of service, efficiency, availability, flexible configuration, scaling
  - They are implementing their own networks, to some extent

New networking solutions

- Started with CDNs (Content Distribution Networks), or OTT (Over the top networks)
- More recently SDN (Software Defined Networking), implemented in private infrastructure (data center, private WANs)
- Fast Lanes at the edge, sometimes paid by application/content providers

Two co-existing networks and more …

- Original Internet
  - Public, based on protocols, distributed operation, provided by multiple providers
- Cloud-based Internet
  - Edge is the same, but the cloud provides both computing and networking services
  - More things based on "configuration", and controller implemented in software, more centralized control
  - The role of Open Source, compared to protocol specification
- Fog Computing/ Networking
  - To decentralize (extend) Cloud-based Data Processing/ Storage Services to the Edge of an Enterprise Network, e.g. to support Internet of Things (or the Industrialized Internet)

Summary

- Network technology is not purely technical, but involve many issues in governance
- Network is evolving to better satisfy all the new demands
- There are some “clean slate” proposals for future Internet
- As engineers, we need to appreciate these high level trade-offs, besides how protocols work