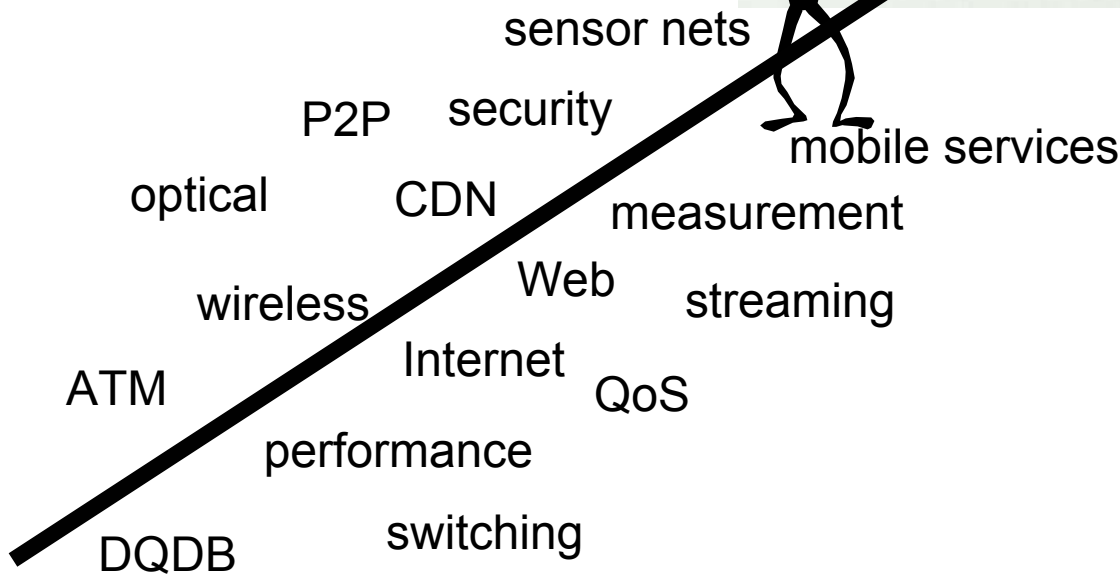


# Looking Back and Looking Forward

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# Where have we come from?

- 10 years ago: IP versus ATM
- since then:
  - QOS
  - network calculi
  - intserv diffserv
  - signaling: RSVP
  - high speed routers
  - WWW protocols, caching
  - CDNs
  - streaming
  - LRD traffic
  - power laws
  - TCP, closed loop control
  - multicast
  - measurement
  - active networking
  - traceback, DDoS
  - BGP pathologies
  - VoIP, SIP
  - IP-over-\*
  - .....

The definition of **success** is in the eyes of beholder

# Challenge: scale, complexity

- growing gap between:
  - scale, complexity, heterogeneity of networks
  - ability to capture (measure), model (abstract), and ultimately understand their behavior
- some successes: performance!
  - closed-loop TCP models
  - large scale fluid models, simulation

# Challenge: on beyond data plane performance

## □ Q: is performance really *the* major roadblock?

- "robustness"
- "complexity of control"
- maintainability
- evolvability
- adaptability
- reconfigurability
- security
- manageability

the ".....ities"

## □ Fundamental advances here are hard!

- "efficiency" not the most important measure
- little/no past work
- metrics and models still to be defined

# Example: soft state control

- conventional wisdom: “soft-state is robust, less complex than hard-state signaling”
  - really?
  - how to define “robustness”?
  - how to define “complexity”?
- posing/answering such a question is:
  - *hard*: no well-accepted models, paradigms
  - *easy*: little/no past research
  - *important*: a fundamental question

# Choosing problems

- Look to industry: manageability a key concern
  - *models* needed to reason about network behavior
  - *measurement* needed to understand current behavior
  - increasing *complexity*
    - McKeown: by some measures IP already more complex, still less reliable, than telephone net
- “applications rule”
  - sensors nets, wireless/mobility
  - publish/subscribe architectures
  - application overlay networks
  - games, VR

# Summary: advice to students

- *lots* of successes to be proud of!
  - definition of success in eyes of beholder
- *lots* of interesting unanswered questions
  - fundamental questions with large half life (thinking outside the box)
  - “on beyond performance”: the “...ities”
- applications, applications, applications

# Questions

- ❑ why so little biodiversity in research areas?
- ❑ why aren't there more Jim Roberts?
- ❑ all the action at the application level?
- ❑ QoS, multicast within provider's network?