COMPLEXITY IN NETWORK ARCHITECTURE

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Thoughts on architecture

Modernist view

Less is more.

Ludwig Mies van der Rohe

Post-modernist view

Less is a bore.

Robert Venturi

Form follows function

- New functions add to the form
  - More users represent larger span of tastes, needs and interests
  - Technical capabilities open new service options
  - New business models require system support
- The architecture of the evolving system is increasingly complex

Complexity a challenge

- Cannot be avoided, must be managed
  - Research phase
  - System design
  - Standardization
  - Operation
  - Evolution
- Tradoff with performance and functionality

Design paradigms

Commodity components and decentralized systems

- Simple systems in large numbers
- Self-organizing with synchronized states
- Predictable and controllable aggregate system behavior

Reduced set of network services

- Coordinated by service-specific signaling
- Enhanced by functions at the edges

A reduced-service set architecture

A controlled-load service

- Packet-scale buffering for low delay
- Probe-based admission control
  - Low priority for probes
  - High priority for data
- Tuneable FEC for quality enhancement

QoS PDQ – Transport-level differentiation

- TCP for batch data
  - Free admission, rate-controlled flows
- PBAC controlled UDP for streams
  - Inelastic flows, load-controlled aggregate

The simplified guaranteed service

- Shaping in all nodes
  - Delay bounds for any number of hops and loads
  - Makes the reservation state additive
- Service specific signaling
  - Messages carried lossfree in service
  - Reservation state is a shared variable per link
  - Fast path processing
    - Reservation: add rate to shared state variable; subtract to deallocate
    - Admission control when reservation state reaches max, request is dropped
  - Garbage collection after lost messages in the background
    - Short time-scale for dropped reservation messages
    - Long time-scale for loss of other messages due to transmission errors and link failures
- Combined with stateful routing for traffic engineering
  - Circuit-switched backbones and VPNs

Research agenda

- Complexity metrics for distributed systems
  - Allow quantitative comparisons
  - Computable and applicable
  - Link to performance metrics for tradeoff analysis
- Design methodologies
  - Modularization, patterns
  - The role of aesthetics
- Standardization process
  - What should be standardized?
  - System evolution and ability to upgrade
  - Interoperability and feature interactions