Direct Access Networks:
A Paradigm for Robust Dynamic Extensibility

Prof. Steven S. Lumetta
(joint work with Prof. Muriel Medard)

University of Illinois at Urbana-Champaign
Dept. of Electrical and Computer Engineering
Coordinated Science Laboratory
Direct Access Networks:
A Playground for Adaptive Computation

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Outline

• direct access networks
• challenges
  – link recovery
  – dynamic extensibility
  – dynamic capacity
• methodology for study
• combine mobility and services
• conclusions
Extending Network Infrastructure

- connectivity demands
  - rapid growth
  - unpredictable
  - incremental
- ad-hoc infrastructure extensions
  - aggregation
  - hierarchical organization
  - periodic overhauls
Aggregation and Overhauls

new end user or network

network/ISP

backbone network

switch (e.g., WDM, SONET, ATM)
Aggregation and Hierarchy
Growth by Direct Access

new end user
or network

network/ISP

backbone network

switch (e.g., WDM, SONET, ATM)
Just Add Switches?

- Each switch adds:
  - Cost (very expensive)
  - Additional latency
  - Power consumption
  - Jitter

Direct access decouples access from routing.
Direct Access Components

- (mobile) end user
- access node
- access ports
- backbone network
Characteristics of Switches and Access Ports

- owned by regulated industry
- provide reliable connectivity
- control available bandwidth

- switches
  - expensive
  - installed to meet routing needs

- access ports
  - inexpensive
  - available for lease/rent
  - variable backup options
Access Node and End User Characteristics

• federated ownership (ISP’s/individuals)
• access nodes
  – scalable multiprocessor
  – provide home/proxy computation
  – negotiate bandwidth
  – support base stations for mobile users
• end users
  – possibly mobile
  – variable bandwidth demands
  – variable computation demands
Advantages of Direct Access

• contrast with alternatives
  – uses existing infrastructure
  – fewer owners/operators along path
  – inexpensive to implement
• new capabilities
  – dynamic extensibility
  – dynamic capacity (bandwidth)
Dynamic Extensibility Example

Champaign-Urbana

Springfield

Decatur

Chicago
Dynamic Extensibility Example

ad-hoc
FEMA network
Dynamic Extensibility Example

nomadic computing
Dynamic Capacity Examples

• conference hotel
  – week 1: philosophers
  – week 2: ACM SIG
  – week 3: W3 Net Surfers’ Club

• NASA
  – supernova catalog
  – shuttle mission video broadcasts
  – first film from surface of Titan
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Recovery of Physical Links

• desired properties
  – localized (distributed decisions)
  – dynamic, available rather than reserved
  – support general topology
  – avoid duplicated effort

• approaches
  – self-healing rings
  – loopback restoration
Self-Healing Rings

reserved bandwidth

active backup
Loopback Restoration

dynamic bandwidth

passive backup
Advantages of Loopback Restoration

• more general topology
  – dual-path mesh (vs. ring coverage)
  – arbitrary topology with backup priorities
• dynamic exploration
  – uses available bandwidth
  – no active backup
  – finds any possible backup path
• no recovery reorganization for new switches
Loopback with Direct Access
Loopback Solution
Problems for Recovery Implementation

- fault detection and localization
- real-time backup path exploration
- distributed recovery scheme
  - switches and access ports
  - support for dynamic extensibility/capacity
- involve access nodes in recovery?
Problems for Dynamic Extensibility

• access port setup
  – node-owner/billing identification
  – access negotiations
  – automated?

• access node routing
  – may not have home node
  – faster than wired name propagation?
Problems for Dynamic Capacity

• arbitration of bandwidth
  – involve only one link (switches and access nodes)
  – switches direct access port control
  – pricing scheme?
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Methodology for Study

- simulation of wireless connections
  - simpler than real hardware
  - measure effect of improvement
- emulation of TDM direct access network
  - Myrinet-based
  - using active control (an SMP)
Myrinet-Based Emulation

10 MB/sec TDM

Myrinet properties
• 160 MB/sec links
• 8-way crossbar switches
• round-robin scheduling

backbone traffic generator
Opportunities with Direct Access

- seamless mobile access
  - connection handoff (cellular, etc.)
  - name propagation/data forwarding
  - disconnected filesystems (MFAS)
- scalable internet services
  - image distillation (TranSend)
  - prefetching (Smart WWW Proxy)
  - formatting (Wingman)
  - scalable network service architecture (TACC)
Fun Problems

• connectivity
  – suspend and reinitiate
  – buffer data streams
  – control data management strategy
• manage computation
  – home node or proxy
  – trade computation for bandwidth
  – allocate computation resources
  – store results where
• advertise mobile services
• broadcast commonly requested data
Conclusions

• direct access networks
  – decouples access from routing
  – reduces depth of hierarchy

• enables
  – dynamic extensibility
  – dynamic capacity

• problems
  – recovery
  – managing adaptation