Challenge Problems

“Novel Protocols and Network Configurations” Team
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Team Approach

- Pick apps that benefit the Internet
  - people care about the problem
  - require programmability in network
  - infect Internet with active net virus... :-)
  - work through issues end-to-end

- Example I: Active Routing (ARC, Detour)
- Example II: Active Service Attack Prevention (ASAP)
Challenge: Interoperability

- Towards PLANTScript
  - Internet -- hook networks together
  - Interactive network -- hook active networks together

- Federated administrative domains
  - No single node OS, API, prog lang Required if system is to scale
  - Security, perf. isolation, local decision making, upgrade path, ease of devel.
Outline

- Background
- Interoperability Issues
- Example Apps: ARC/Detour and ASAP
- Deployment Challenges
ABONE tunnels over Internet

- Hosts
- IP Routers
- Active Network Elements
“Active Network Architecture”

Application -> Execution Environment (e.g., ALIEN)

Application -> Execution Environment (e.g., ANTS)

Node Operating System (e.g., Nemesis, Scout, Linux, NT?)
ANEP demultiplexes to EEs

- Well-known UDP/IP Port for ANEP
Challenge: Scale to 1K Nodes

- Assume a single execution environment standard?
  - No single solution best for all apps
- Assume a single node OS standard?
  - Inflexible, hard to upgrade
- Assume backward compatibility with node OS API?
  - Still need trust boundaries
Interoperability

- Heterogeneous clouds of homogeneity
  - part PLAN, part ANTS, part inactive
  - part Scout, part Nemesis, part SecureXOK

- End to end solution requires:
  - Active border gateways for translation, security domains
  - Communication and resource allocation between execution environments
Example #1: Active Routing

- Internet routing is performance insensitive
  - AS path length, early exit, private peering
  - at best, hand tuned policy

Even so: Internet is black box
- hard to know where the problems are
- no multipathing/load balancing
- poor congestion control for short flows
Opportunities for Active Nets

- At single router
  - program control over policy decisions
  - measurement based
- Within admin domain
  - cooperating routers
- Across domains
  - active BGP?
Active Router Control

IP Router/Forwarders co-located with Active Elements:

IP Router/Forwarding Tables

LAN

Routing Policies and Decisions (and New Services)

Active Element
Implementation Status I

- Early experiment by Bill Marcus
  - Bellcore protocol booster kernel on P.C.
  - Control Cisco 7000 through policy based routing (PBR) interface

- Current work by Osman Ertugay at Penn
  - Java program controlling Cisco 3600 through PBR, running on P.C.
  - Working with 3Com on CB 3500 platform
Implementation Status II

- Project by Columbia & Bay/Nortel
  - Netscript on Accelar
- Programmable gateway:
  - Router, firewall, analyzer/shaper, caching server... (boundary smarts!)
- Investigate SW architecture and HW support
Detour Architecture: Cooperating Active Routers

- Detour nodes at network borders
- Packets routed along tunnels
- Support for non-Detour networks
- Nodes aggregate and transform traffic from sites
- Nodes measure network behavior
ARC becoming possible in COTS
Research/Engineering Issues

- Hierarchy necessary to scale
- Extend with ARC<->ARC protocol
  - ARCs will be organized in Admin. Domains
  - Arbitrary ARCs cannot control routers
  - ARCs resemble active firewalls
- At border gateway, need translation/communication between EE’s
Example #2: Denial of Service

- Easy to protect server hosts
  - Resource domains, interrupt masking, firewall shielding on host itself
- But service is unprotected between client and server site
- This problem must be solved with network-embedded functionality
Denial of Service attack

Cross traffic in an Internet
End-to-End Activations

Resource Management Challenges
Need to control multiplexing

E.g., assign L3 bandwidth 66%/33%
Fair Queuing Code for an A.N.E.

- Discriminates between “flows”
- Separate queue for each current flow
- Queues are serviced “round-robin”
Research/Engineering Issues

- What is the relationship between the EE and the NodeOS?
  - What can A.N. applications request?
  - How does NodeOS mux EEs?
- What is the language used for loading disciplines?
  - Per-EE (PLAN code generates Netscript?)
  - RSVP interpreted by A.N.E.?
Deployment Challenges

- EE interoperability
  - Will we need an EE-interoperability EE?
  - Or will we be limited to a subset of nodes?
- Difficulties with P.L.-based security
- Local Autonomy vs. Global behavior
- Varying capabilities of NodeOS?
- Challenges use ANEP, ABONE, EEs
Results, if it works:

- Every commercial service will need it
- Provides big incentive to Internet services to extend ABONE for us
- But, of course, it *is* programmable...
Interoperability necessary and fun, but not in workplans for many projects.
- Takes lots of time and coordination.
- Requires more staffing and $$

Cautionary: temporary infrastructure often outlives its inventors...