Active Networking on the ENIAC 2000
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SwitchWare is joint work with Dave Farber, Carl Gunter and Scott Nettles of Penn, and Bill Marcus and Dave Sincoskie of Telcordia. See:
http://www.cis.upenn.edu/~switchware
From Store-and-Forward

1. Dequeue Packet from Input Port
2. Determine “best” Output Port
3. Queue Packet on Output Port

To Store-\textit{Compute} and-Forward!
Smart Hosts + Dumb Switches = Passive Nets

Smart Hosts + Smart Switches = Active Nets
Active Network Architecture

- Application
  - Execution Environment (e.g., ALIEN)
  - Execution Environment (e.g., ANTS)
- Node Operating System (e.g., Nemesis, Scout, Linux, NT?)
E.g., the SwitchWare A.N. Architecture
Packet Language for Active Networks (PLAN): Ideas

- Domain-Specific Language for A.N.
  - Active packets of ML-like code (but restricted for security & performance)
  - Active extensions for restricted tasks (such as link-layer access)
  - “Glue language” to build active applications (think of a UNIX shell for A.N.)

- PLAN internetwork demonstrated
  - Reported in IEEE INFOCOM ‘99
The ALIEN Active Loader

Focus on generality and security
- module thinning for locally enforced “views”
- crypto. Credentials extend to remote case
- active packets and active extensions
- all written in Caml with restricted runtime

Applications to LAN bridging (SIGCOMM ‘97), secure active ping, ...

ALIEN in an Active Element

Three layer architecture

- Libraries
- Switchlets
- Core Switchlet
- Loader
- Runtime (Caml)
- OS (Linux)
## Active Packets in ALIEN

- If ANEP header indicates ALIEN
  - SANE processing as part of ANEP
  - Code portion is loaded
  - `func` is called with code, data, and `func` name as arguments

<table>
<thead>
<tr>
<th>link layer header</th>
<th>ANEP header/SANE auth</th>
<th>code portion</th>
<th>data portion</th>
<th>func name</th>
</tr>
</thead>
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Breakdown of Costs in Alien

- kernel/wire: 26%
- Caml overhead: 20%
- transmission related: 4%
- information gathering: 10%
- marshaling: 16%
- authentication: 25%
Active Router Control (Active Border Gateways?)

IP Router/Forwarders co-located with Active Elements:

- Forwarding Tables
- LAN
- Active Element
- Routing Policies and Decisions (and New Services)
The basic architecture

- Policies
  - Measure
  - Measure

- Router A
  - Route Updates

- Router B
The Basic Opportunity: Internet routing does not utilize the available network topology unless manually configured:

Goal: Resource Discovery and Exploitation!