SwitchWare

Accelerating Network Evolution

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The Problem

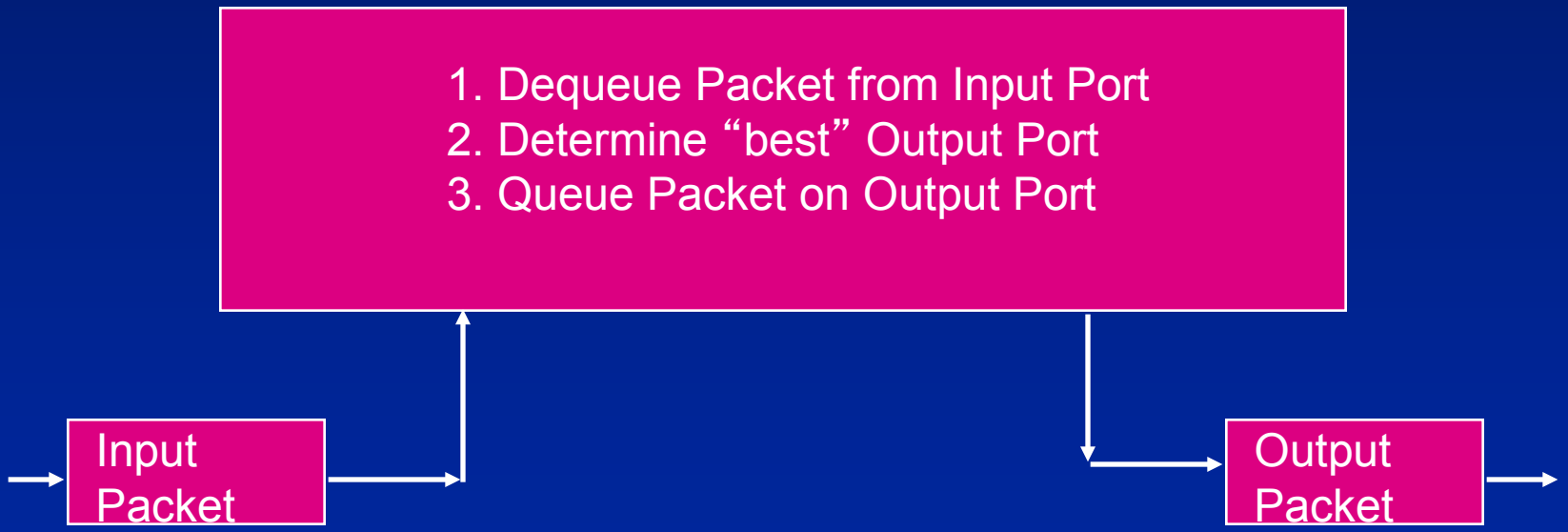
- Pace of network service development **SLOW**
  e.g., IETF->Cisco->ISPs (5-8 years)
- **NEED** for standardization (interoperability)
- IP Packet format **WRONG** level of abstraction!

Approach: “30,000 Foot Level”

- *Programmable* interoperability layer
- *Infrastructure*-provided, e.g., switches, ...
- Programmable (to some degree) by users
- Or, one way to “Active Networks”
- MANY challenges: security, performance,...

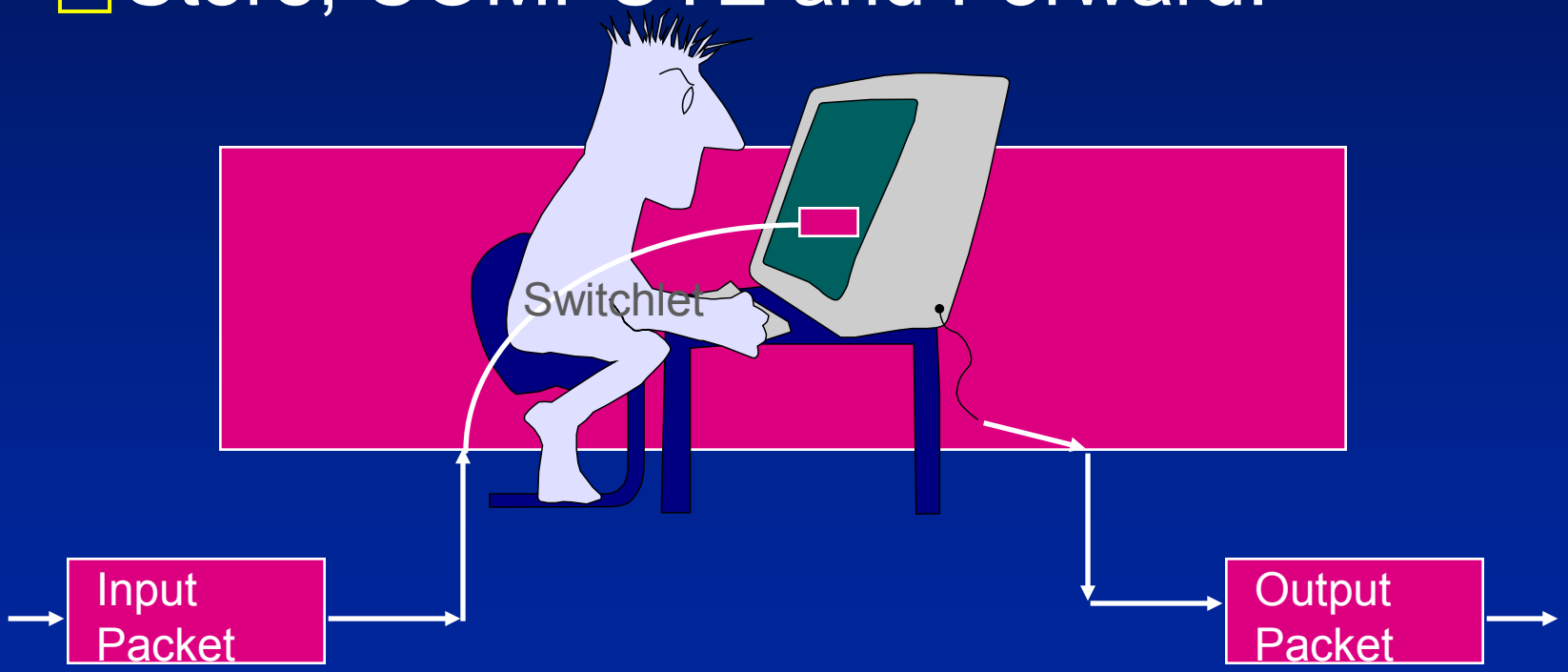
Routing IP Packets

- Model: Store and Forward



SwitchWare switching

- Store, COMPUTE and Forward!



Applications, or Why bother?

- Self-Paying Information Transport
  - » Routing by economics; policy with $$$
- Network Management:
  - » in-band OR out-of-band
  - » inject diagnostics code *as-needed*
  - » e.g., Morris worm code patches
- Dynamic bandwidth aggregation (striping)

Problems

- Performance: Well, yes but *Correctness* FIRST!
- Safety: Good guys can make mistakes...
- Security: Bad guys can program too...
- Network Infrastructure is *shared*
  - » it MUST work (telephony as example)
- Can we get **FLEXIBILITY** *and* **SECURITY**?

Security IS NOT Cryptography!!!

- Security is:
  - *Right information* to
  - *Right people* at
  - *Right place* at
  - *Right time*
- This is *policy*
- Insecure systems exhibit *policy* failures

Security: Enforcing Policy in 3 Parts

- Identification
- Access Control
- Quality of Service
  - » versus “Denial of Service” attacks

A Language-Oriented Solution in 3 Parts

- Switchlet Language for users (SL)
  - » formal semantics restrict programs
- Wire Language for communicating (WL)
  - » formal semantics across boundaries
- Infrastructure Language for Virtual Machine (IL)
  - » formal semantics supported on metal: run-time

What DOESN'T work...

Java/TCL	SL
Java bytecodes	WL
C	IL

Penn/Bellcore Active Router

CAML	SL
CAML bytecodes	WL
CAML	IL

Penn/Bellcore SwitchWare Target

Verifiable ML--	SL
Encrypted Verified Intermediate Language	WL
ML++	IL

Target Platforms

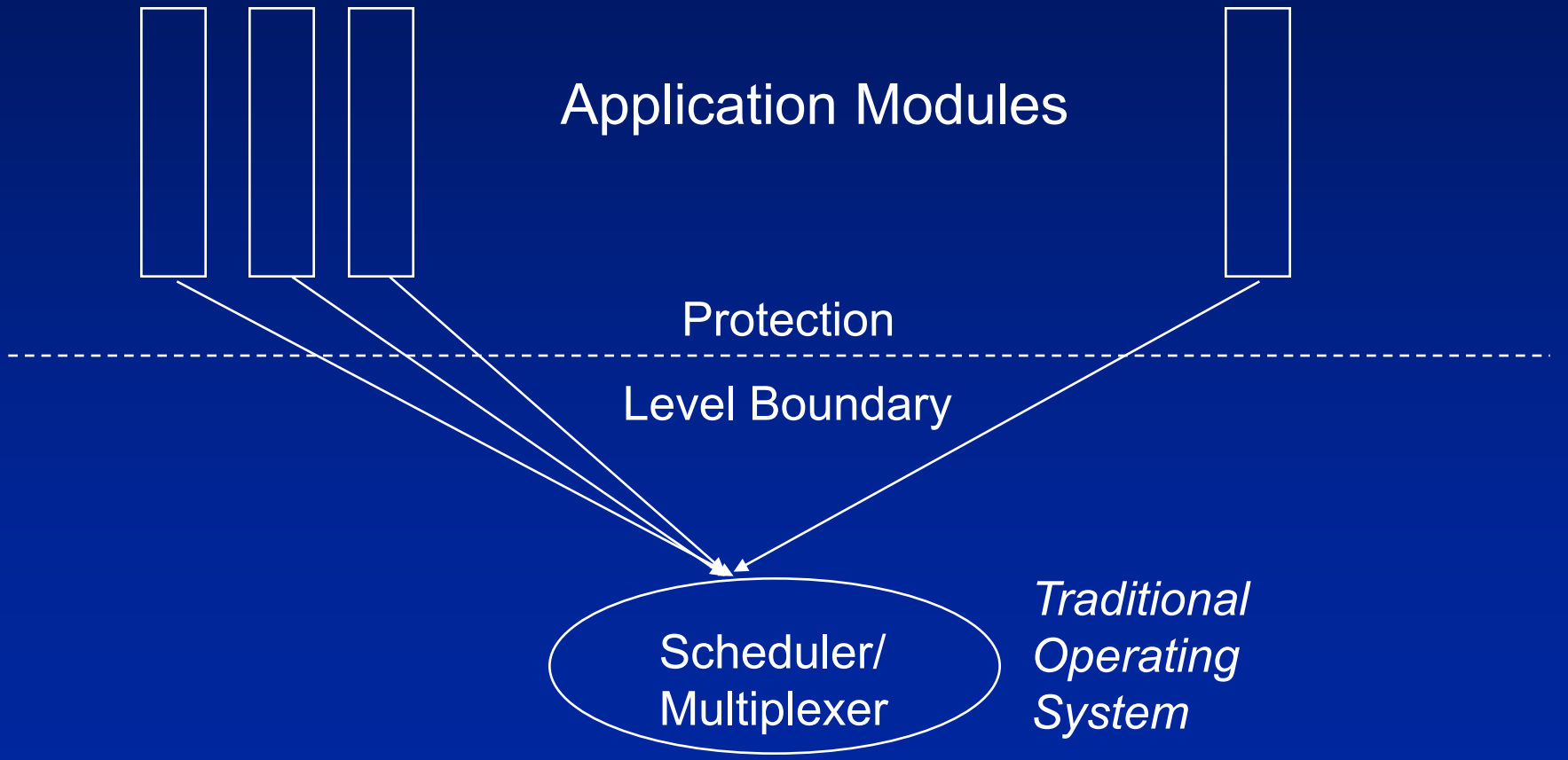
- Shared Memory MP as “Switch”
  - HP Netserver LS (Pentium)
  - SGI Challenge (MIPS R4000)
- ATM and Ethernet Line Cards
- Bellcore OPCv2 ATM cell buffer/mux

Accelerating Network Evolution

- *Programmable services*
- *Extensibility of infrastructure*
- *Security by design, not afterthought*
- *Partitioning resources under policy*
- *Portability and technology independence*

http://www.cis.upenn.edu/~jms/white-paper.ps

Sharing and Security



SwitchWare Contributions to Active Nets

Activity	Enabling Tech.	Platform Develop.	Pgm'ing Models	Middleware Svcs./Apps.	Active Ctls./Algs.	Netw. Ops.
1. Formal Model		***	*		*	***
2. Runtime Env.		**	**	**		
3. Router				**	**	**
4. Security		*	**	**	***	**
5. OPCv2	***				**	

* = relative importance

Project Tracks and Timeline