SwitchWare Lessons Learned

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Contributors:

- SwitchWare a joint project of Penn and Telcordia, supported by DARPA ITO (RCANE supported by NSF)
- Cast Includes: Alexander, Arbaugh, Bogovic, Farber, Feldmeier, Gunter, Hadzic, Hicks, Hornof, Jim, Kakkar, Keromytis, Marcus, McAuley, Menage, Moore, Nettles, Segal and Sincoskie
- Hewlett-Packard, Intel, 3Com & Nortel

SwitchWare history:

- Sincoskie (1990/1): how "best of both" POTS and IP interoperability models?
- Smith proposes S-T-F model in 1993
- Feldmeier and Smith Protocol Boosters project for DARPA starts in 1995
- DARPA Active Networks Program starts in 1996 with Penn&Telcordia; BBN; Columbia; MIT & Arizona

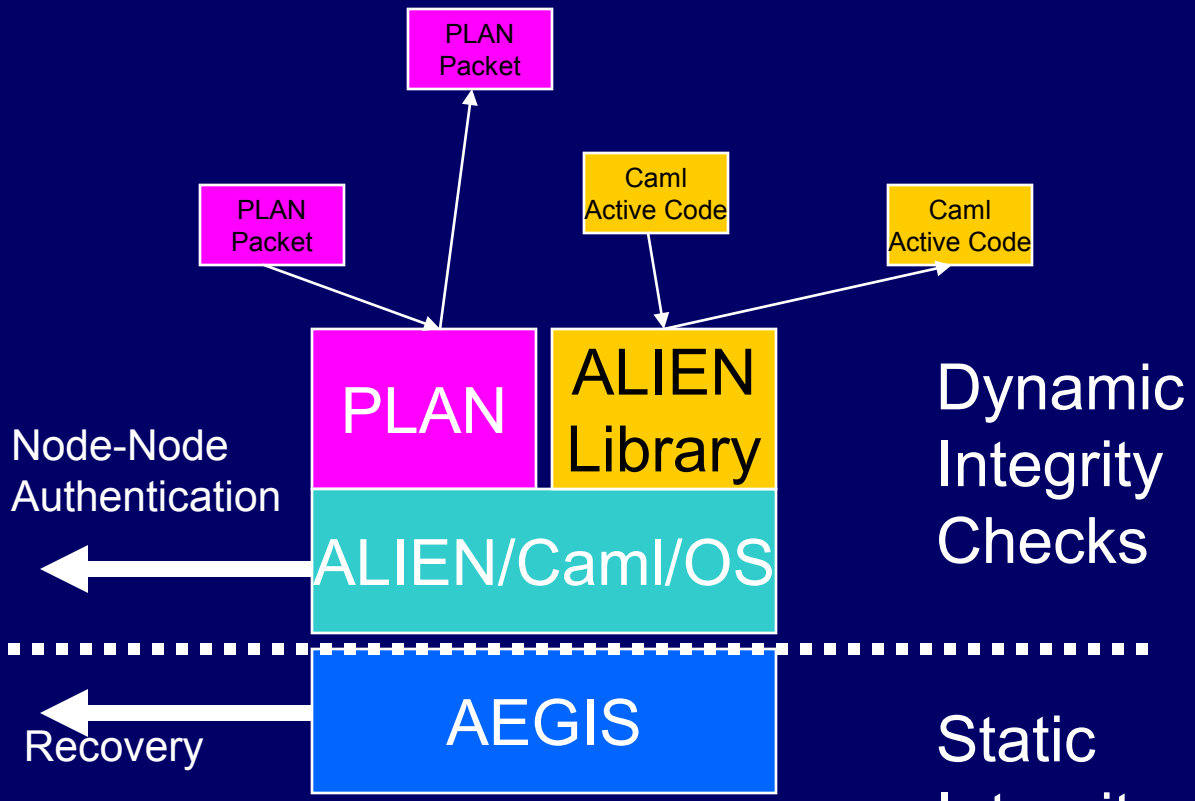
Accelerate Network Evolution

- Create Programmable Nodes; standardize the programming model, not the nodes
- Change from Political Tempo to Technical Tempo
- Balance Usability, Flexibility, Performance and Security

SwitchWare Approach

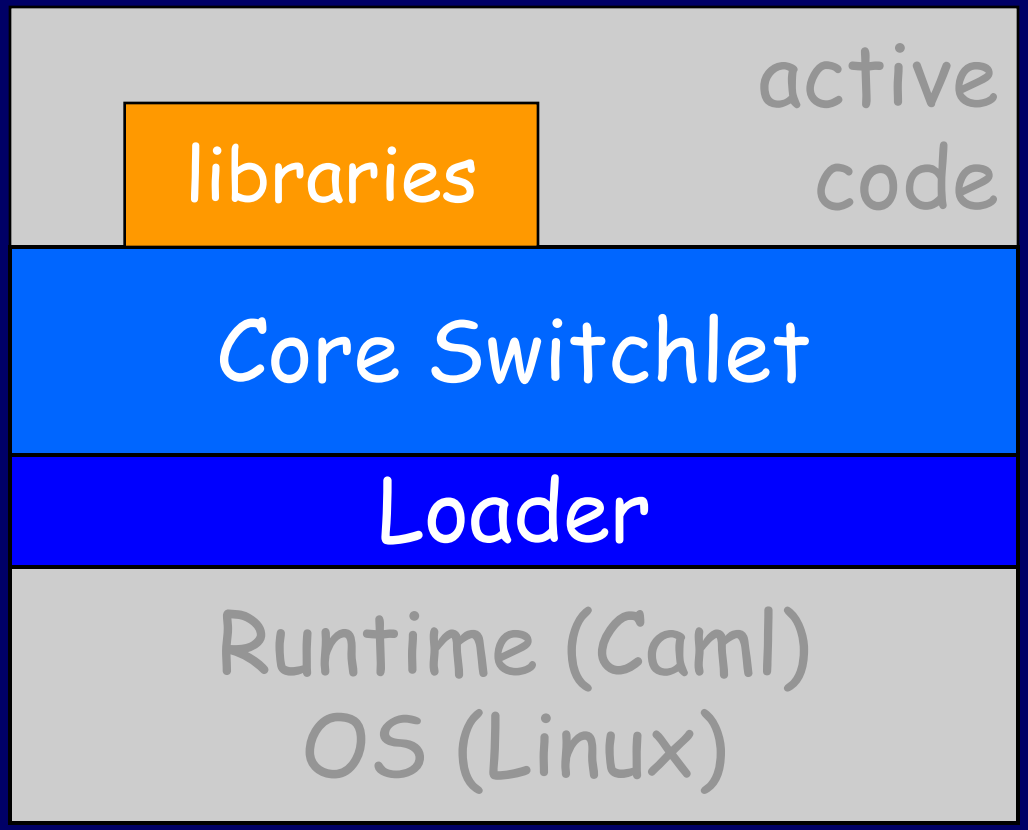
- Modern Programming Language technology can help with safety and security, maybe performance?
- Build flexible node executing programs written in such languages
- Use P.L. type theory to restrict programs for safe multiplexing of node in a network

SwitchWare System Architecture



ALIEN Active Loader

- D. Scott Alexander



Packet Language for Active Networks (PLAN)

- Hicks, Kakkar, Moore, Gunter, Nettles
- Active Packet-based approach
- Highly-restricted domain specific language (a safe "glue" language, like the UNIX shell), extensible via ALIEN
- Active extensions do restricted ("privileged" things)

PLANet

- Hicks, Moore and Nettles
- First active internetwork (ETH and IP)
- Uses active packets AND extensions
- All packets are PLAN programs
- Added "chunks" to PLAN to support encapsulation and packets as data
- Chunks enable novel active firewalling

Results in A.N. Program, I

- 1st Active Application (Active Bridging)
  - →1st SIGCOMM paper on A.N. (1997)
- 1st Secure Node Environment (SANE)
  - →1st Secure Bootstrap of A.N. node (AEGIS)
- 1st Active Internetwork (PLANet)
- 1st Formal Specification of A.N. EE (PLAN)

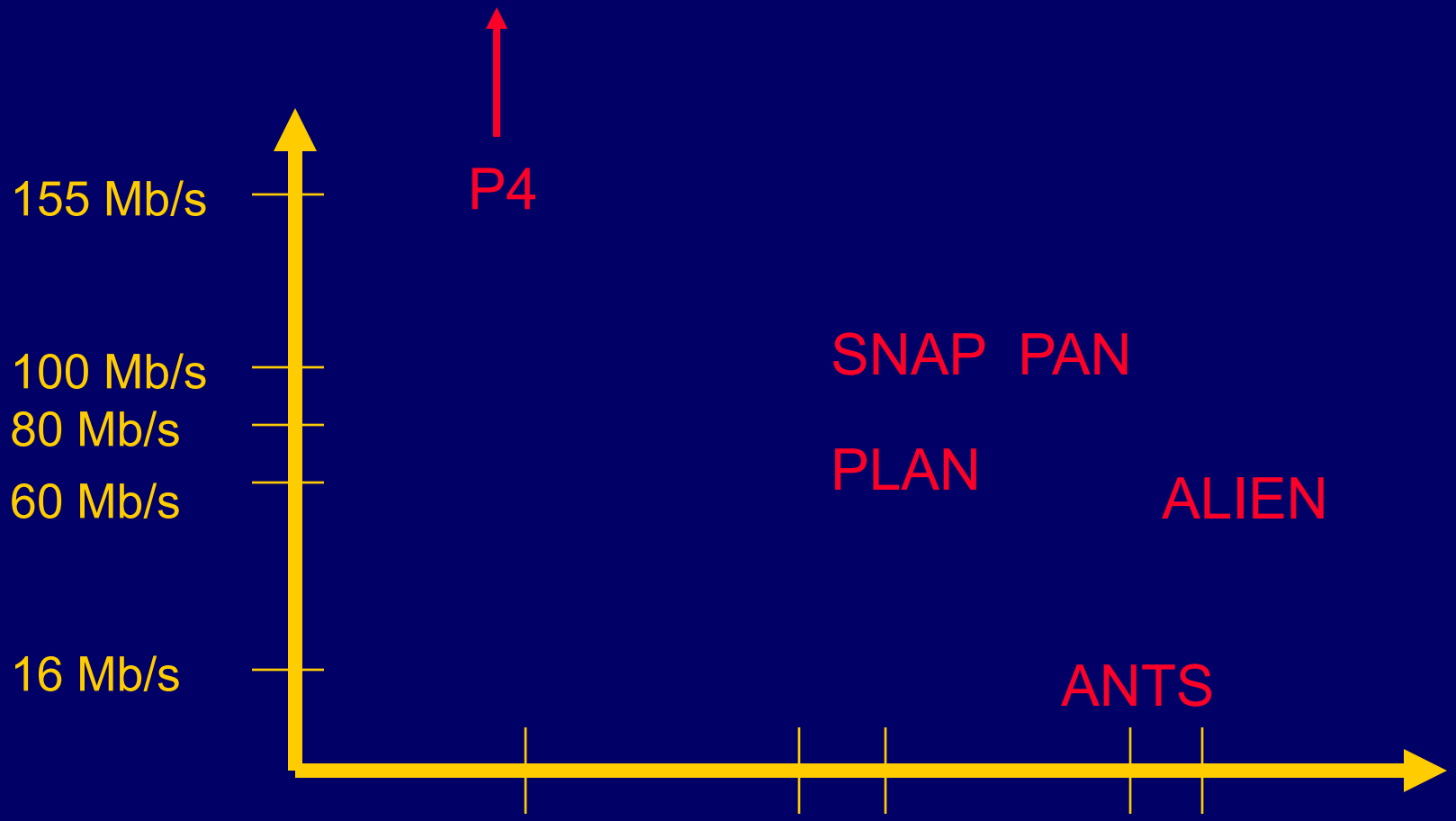
Results in A.N. Program, II

- ALIEN Active Loader and PLAN allow SwitchWare node architecture to handle both active extensions and active packets
- 1st Hardware A.N. element (the P4)
  - → Operates at OC-3c ATM speeds
  - → Dynamic FEC protocol booster for TCP
- Definition of ANEP, work on ABONE

Results in A.N. Program, III

- Telcordia Publish/Subscribe Application
- Interoperation with Protocol Boosters Infrastructure (as well as Netscript and Detour - Team 1 Demo 9/99)
- Resource- Controlled A.N. Environment
  - → Uses Nemesis as NodeOS (w/Cambridge)
- Piglet Operating System
  - →Used in SQoSH system

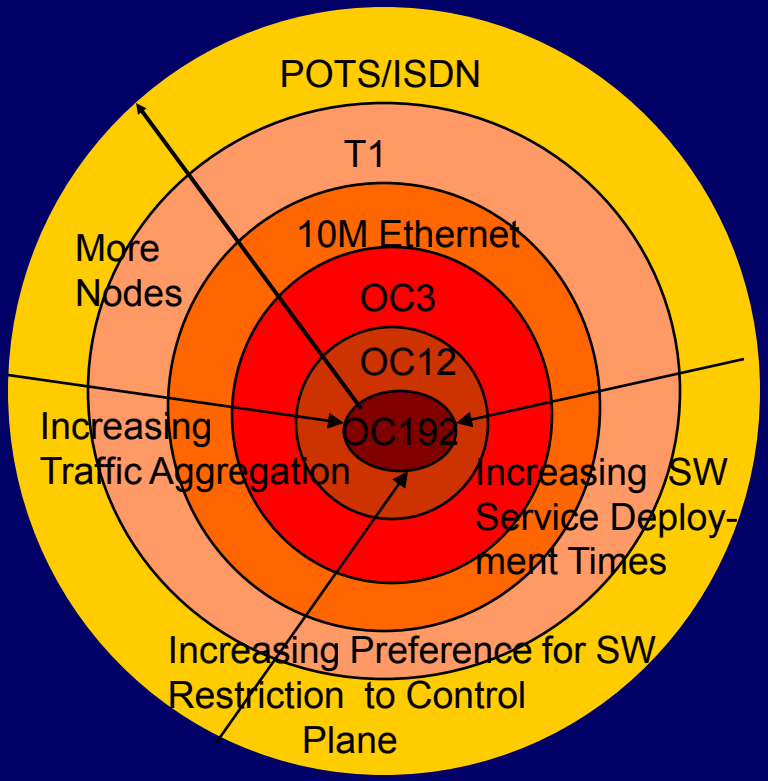
Perf. Vs. Flexibility Tradeoffs



Lessons Learned

- Restricted P.L. for packets a win
- DARPA vision dynamics hard on project
- Active Applications hard
- So far: interoperability problems not removed; just moved.
- Performance acceptable in huge "donut"
- Technology Transition already underway

Activation potential at various current line rates:



Mistakes Made

- CAML technical win, marketing lose
- Suboptimal coordination between Penn and Telcordia during some periods (P.I. falls on sword on this one……)
- Did not allow enough time for network versus node work (should have been 5-6 year project, not 3+)

Things Not Done

- Explore telephony examples from proposal
- Demonstrate convincing applications
- Replace O.S. with P.L. runtime
- Red-team attacks of A.N. security
- Demonstrate Economic Algorithms or SPIT (but FBAR is a good start)