



Active Networks

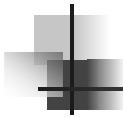
State-of-the-art

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Background

- Active Networks is about programming the network infrastructure as support of customised communication services
 - Active = dynamic programmability and control
 - Customisation = user/consumer centric network and services
- Expected major impact: rapid service creation and deployment

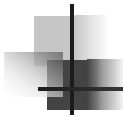


Programmable Networks

OPENSIG - Programmable Networks in telecom oriented approach

- Opening up the switches
- Modelling communication hardware using open programmable network interfaces
- Emphasis on service creation with QoS
- Open interfaces allow service providers to manipulate the network via middleware toolkits
- IEEE P1520 Project follows this approach (standardise programming interfaces for IP routers, ATM switches & mobile networks)

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AN Approaches

- **Integrated (in-band or Encapsulation)**
capsule-based approach - packets may contain both data and active code to be executed at node
- **Discrete (out-of-band or Programmable Switch/Router)**
active code downloaded out-of-band from code libraries/caches

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AN Architecture

Active Packets approach

- Active code is carried by packets
- No active code resides on nodes
- Nodes allow computation up to 7 layer
- Active code executed on the data of the same packet or changes state of the node

Most of the early AN implementations follow this approach

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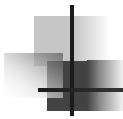


Active Packets

Smart Packets

- Programs completely self-contained and fit entirely in one packet
 - no need for persistent state in router
 - programs cannot be more than ~1Kb
- Operating environment provides security
executable code is dangerous
- Active Network Encapsulation Protocol (ANEP)
 - Smart Packet encapsulated within ANEP packet
 - ANEP packet encapsulated within IP packet
- Active Code
 - Highlevel – Sprocket (much like C)
 - Lowlevel – Spanner (assembler)

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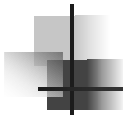


Active Packets

Active IP Option

- Uses IP option field to embed program fragments in an IP datagram
- Two options
 - program fragments
 - language query
- Active Code – TCL
 - Processing is done by striped-down TCL interpreter
- Backward compatible
- Limited to IP protocol

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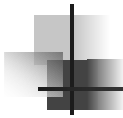
AN Architecture

Active Nodes approach

- Packets contain:
 - identifiers or references to predefined set of functions
 - function parameters
 - payload
- Active code (functions) resides on nodes

Better security and performance

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Active Nodes

ANTS (Active Node Transfer System)

- Network is viewed as distributed programming system
- Packets replaced by capsules
 - capsule include ref to the forwarding routine to be used to process it at node
 - related capsule types form a code group
 - code group is transferred as unit
 - related code groups form a protocol
- Code distribution mechanism
 - code loaded and cached at node
 - some "well-known" routines available at every node
- Java-based prototype

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AN Architecture

Active Packets and Nodes Approach

- Active Packets can carry only simple and restricted code
- Complex code resides in Active Nodes

Usually this architecture allow user to choose actual approach

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Active Packets and Nodes

SwitchWare

- Active Packets
 - same as in active packets arch
 - Programming Language for Active Networks (PLAN) – lightweight, restricted language
 - PLAN programs can call Switchlets
- Switchlets
 - routines which resides on the node
 - can be dynamically loaded
- Active Router Infrastructure

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Active Packets and Nodes

NetScript

- Delegated agents to program and control intermediate network device/node
- Virtual Network Engine (VNE)
- Virtual Link (VL)
- VNE + VL = NetScript Virtual Network (NVN)
- NetScript language to program NVN
- Virtual machine to process scripts
- Active Packets = NetScripts packets
- Active Nodes = VNE

Focus on network programmability

Threat network as a single programmable abstraction

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AN R&D

- DARPA
more then 50 projects
- EURESCOM
P926: CASPIAN
- IST FAIN (Future Active IP Network)

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EURESCOM P926: CASPIAN

- Constructing a dynamic service environment using policies (for mobility, QoS and management aspects)
- Study suitability of AN as flexible, policy driven service environment and to develop active nodes

Participants:

BT, KPN, Telefonica, OTE, Elisa, VTT,
Broadcom, Lancaster University

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EURESCOM P926: CASPIAN

Six individual experimental projects

- **active server interoperability (all partners)**
studies active network interoperability at the node level
- **active router control (Lancaster Uni, Broadcom)**
developing differentiated services and route control interfaces on IP network elements. These control interfaces may be compatible with IEEE P1520
- **active support for mobility (Elisa)**
developing a set of active nodes capable of mobile active overlay. User devices (PCs with a slightly modified mobile IP installed) will have all of their traffic routed through the nearest active nodes connected to the Internet

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EURESCOM P926: CASPIAN

Cont.

- **active email service (Telefonica, OTE)**
studying active anti-spam filtering and active attachment conversion
- **composition of heterogeneous active services (KPN)**
studying how individuals can compose their own services from the components developed by the project
- **management of active services (BT, KPN)**
implements active service management, utilizing policy based management techniques for service deployment and access

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CASPIAN Architecture

- Divide programmability according to requirements
- Active router
 - OSI layer-3 functions
 - embedded scripts or programs, from trusted sources
 - low memory and computational power
- Active Server
 - application layer active networking
 - many specialized nodes
 - node supporting active caching require high-performance I/O
 - transcoding node requires efficient maths operations

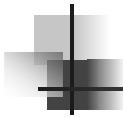
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CASPIAN Active Route Control

- Build programmable router
 - in the spirit of IEEE P.1520 element control
 - provide layer-3 support to active services
- Define programmable abstraction and interfaces enabling control of routing and scheduling
- Two levels of “active networking”
 - “L” interfaces for fine grained configuration
 - uploading active code (i.e. switching between MPLS and DiffServ QoS management)

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