Multimedia Data Distribution and Processing in IP Networks – Active Network Legacy

Eva Hladká, CESNET & Masaryk University, Czech Republic

The Ninth International Conference on Networks, ICN 2010

Menuires, The Three Valley, 12. 4. 2010

Lecture Content

1. Data distribution in IP networks
2. Virtual multicast
3. Active networks
4. Programmable router $\longrightarrow$ Active element
5. Data processing on AE
6. Demonstrations
7. Conclusion and Future work

Data distribution in IP networks

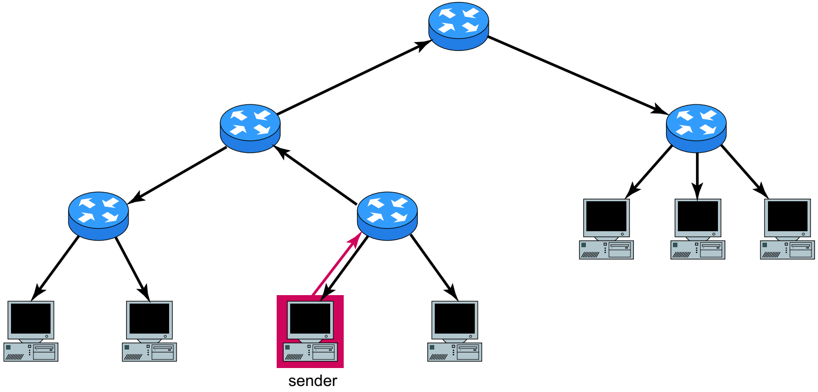
- Generally: data transport from source to n goals
- from 1 source to 1 goal
- from 1 source to n goals
  - IP multicast
  - Virtual multicast

IP multicast

- At most one data copy per link
- Network property (hop by hop, not end-to-end service)
- Not reliable (best effort, UDP, group address)
- Range of spread is limited by TTL (Time To Live) in packet
- Protocols
  - Group management – Internet Group Management Protocol (RFC 1112), IGMPv2 (RFC 2236)
  - Routing – Source Based Tree, Shared Tree (Core Based Tree)
- Properties: scalability, problematic accounting, not reliable service, easy attack goal

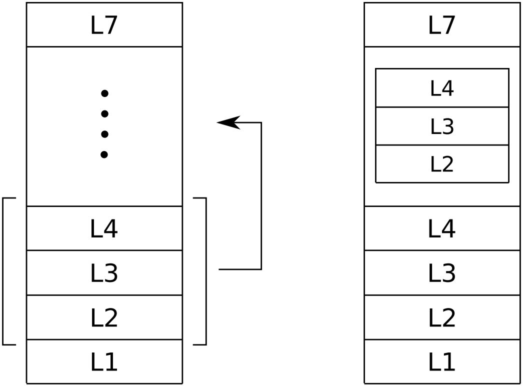
Multicast distribution tree

– At most one data copy per link.



Virtual multicast

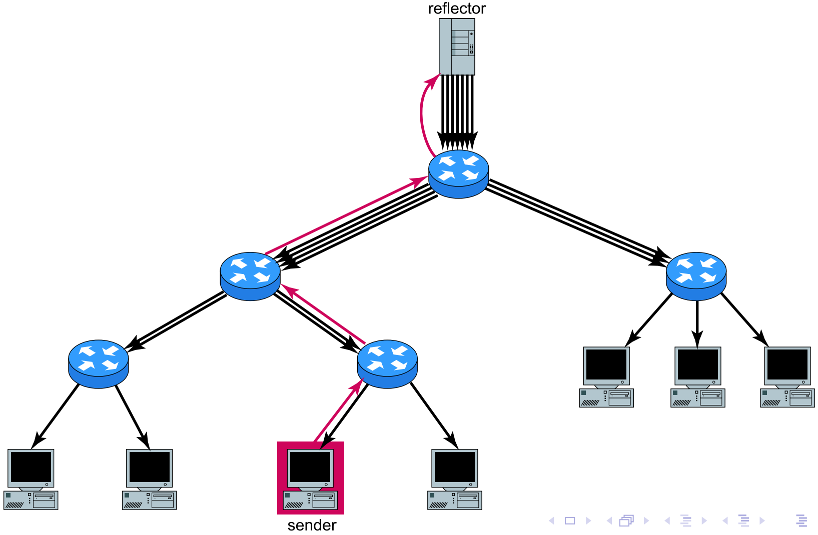
Virtual network is an overlay network with functionality demanded by application and mapping to interconnecting network.



Virtual multicast is a realisation of data distribution $1 : n$ in a virtual network.

Virtual multicast distribution tree

– One data copy per host.



Advantages × disadvantages of virtual multicast

- – efficiency, higher network load
- – scalability
- + independency on network services
- + individual transport by end-client demands
- + managing during the transfer
- + security

Active networks

Passive transport medium $\longrightarrow$ distributed computing environment

- interior nodes provide user managed data processing
- passive links + active (programmable) nodes
- application examples: caching, video processing, reliable multicast, ...

Active networks - architectures

- Active packet
  - program code is inside in each packet
  - program language packet NetScript
  - flexible, limited, big overhead
- Active nodes
  - program is injected to the node before data transfer
  - usual programming languages
  - statefull, security
- Combination active packets and active nodes

Active networks

- new concept in networking
- 1995–2004
- way, how to realise virtual/overlay networks
- applications

Virtual network and Active elements

Virtual network construction:

- On application level – tunnelling
- Overlay network base on replication elements
  - Active elements (AE) as a replication elements

Active element is programmable network element

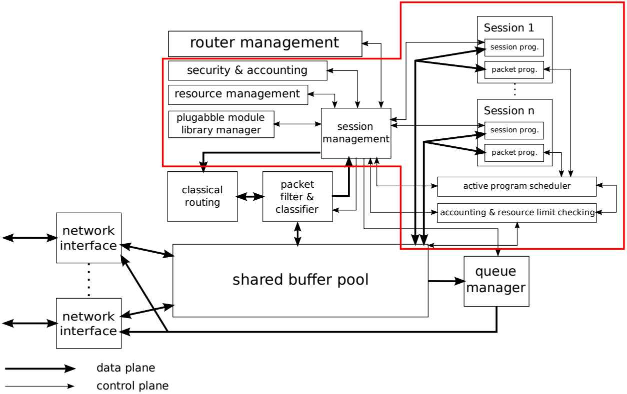
- AE works on application level and could be managed by user
- AE process and resend data
- AE is programmable on application level
  - AE does not intervene to networking stack on standard networks levels

Examples of the AE functionality

- Data replication
- Transport through firewalls
- Data formats translation
- Security of transferred data
- Data monitoring
- Logging and accounting
- Caching
- Multiple streams synchronisation

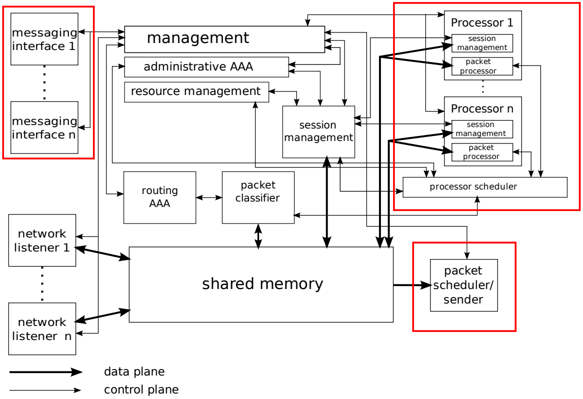
Active element evolution 1

- First step: General active router
  - Concept of programmable network on level network elements (L2, L3, L4)
  - On L7 only prototypes
  - Leaved by the complexity, stability and price



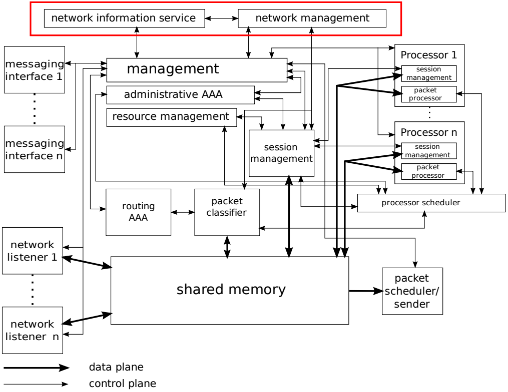
Active element evolution 2

- Second step: move to application level – active element
  - Independence on network elements, flexibility
  - Lower efficiency

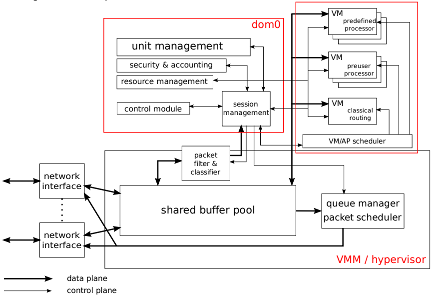


Active element evolution 3

- Third step: scalability
  - Active elements network
  - Distributed active element
  - Better efficiency



- Fourth step: Virtualisation AE
  - Better efficiency in return on network elements?
  - Complexity and price ?

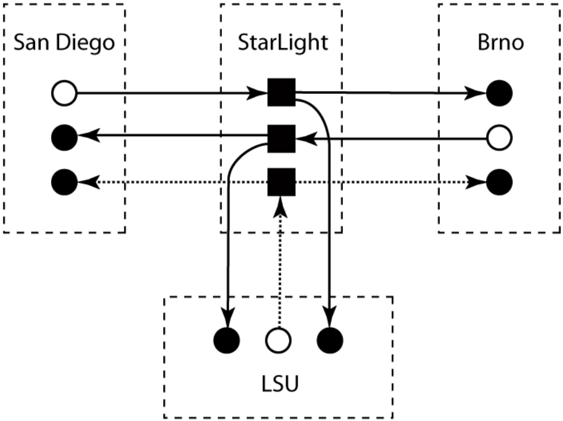


Active element performance – I

- Active elements used for replication 1,5 Gbps streams
- Dual AMD64 Opteron 250 (2,4 GHz CPU, 4 GB RAM)
-

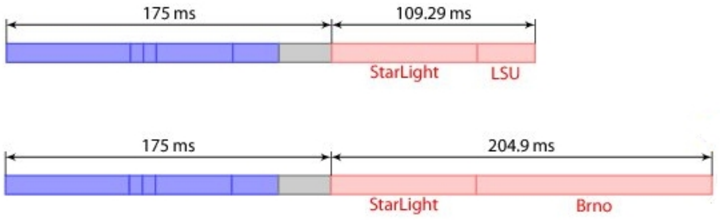
Throughput [Gbps]	Packetloss [%]	CPU load [%]
1.8	0	52
1.9	0	55
2.0	0.01	60
2.1	0.04	76
2.2	1.7	80
2.3	7.1	84

Active element performance – topology



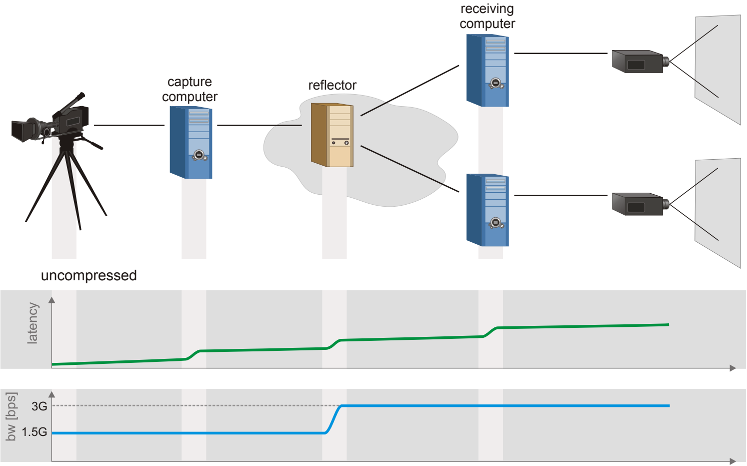
Active element performance – II

- Active element delay: 13 ± 2 ms
- Circuit delay:
  - San Diego $\longleftrightarrow$ StarLight: 78.2 ± 0.2 ms (routed)
  - Louisiana $\longleftrightarrow$ StarLight: 31.09 ± 0.04 ms (switched)
  - Brno $\longleftrightarrow$ StarLight: 126.7 ± 0.3 ms (routed)



Active element performance – III

- Connectivity scheme with time axis



Efficiency upgrade – Distributed AE

- Data stream is divided to substreams and each of them is precessed separately
- Distributed AE could be part of an AE network
- Distributed AE is still user controlled
- It can fill line of any capacity

Active element – secure communication

- IP Multicast – shared key
- Virtual multicast with AE
  - serial distribution and processing on AE – individual key
  - solution with VPN, virtual traffic division

	no VPN	UDP VPN	TCP VPN	TCP VPN + HTTP proxy
pchar latency [ms]	3.51	3.69	3.94	3.93
iperf jitter [μs]	6	6	9	13
pchar capacity est. [Mb/s]	39.8	35.2	20.1	19.8
iperf packet loss @ 30 Mb/s [%]	0.0	0.0	0.0	0.0
iperf CPU idle @ 30 Mb/s [%]	48.9±0.2	41.7±0.4	44.5±0.4	42.6±0.4

  - federation usage for authentication and administration of admitting points

Applications

- Simple videoconference support
  - From Y2K many groups, regularly
- HD videoconference
  - iGrid 2005 – demonstration the first HD uncompressed multipoint videoconference
- Reliable and secure videoconferencing for medicine consultations
  - Project Ithanet (6th Framework EU)

Applications 2

- Advanced videoconferencing environment
  - Subgroup communication
  - Moderating
  - Video stream composition
- Stereoscopic video
  - Two or multipoint transfer
  - AE is used for stream synchronisation

Special applications – visualisation

- More computing (Grid) oriented
- Combination high volume visualisation in real time in collaborative environment
  - HDTV stream generated in Baton Rouge and its transport to Brno and San Diego
  - In parallel videodata are transferred in internal format of used visualisation protocol
  - Data for visualisation were generated in Baton Rouge and in Brno, or in next places in USA/Europa
    - Data streams in Gbps
  - Goal: to compare possibilities computer visualisation with HDTV, data replication in network, interaction with the computation fro the place of visualisation (San Diego)

Applications – visualisation

Applications 3

Lecture PV177 - Introduction to High Performance Computing

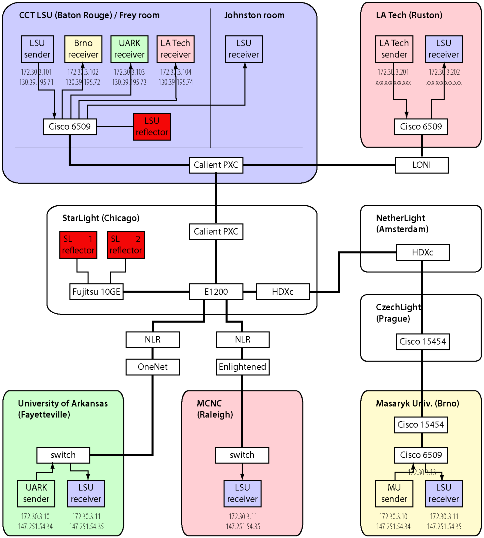
- Prof. Thomas Sterling, LSU, LA, USA

remote 5 organisations (year 2007):

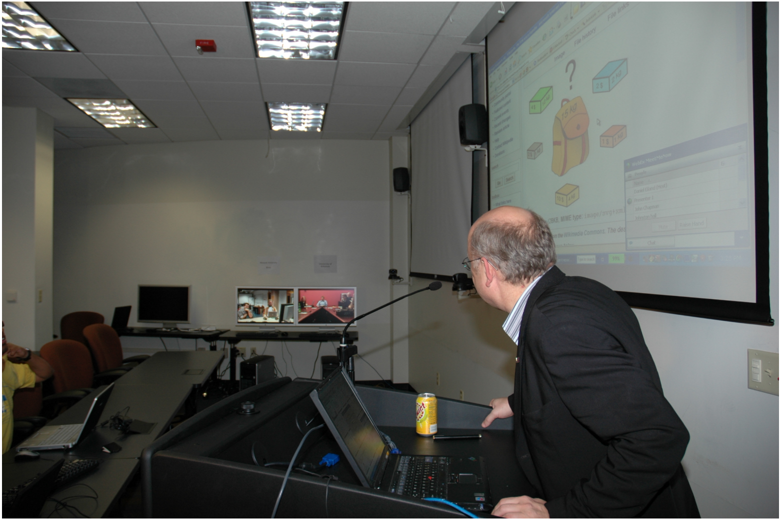
- Faculty of Informatics Masaryk University
- University of Arkansas
- Louisiana Technical University
- MCNC, North Carolina
- North Carolina State University

Spring semester (January – June) 2007, 2008, 2009, 2010

Data Distribution for PV177



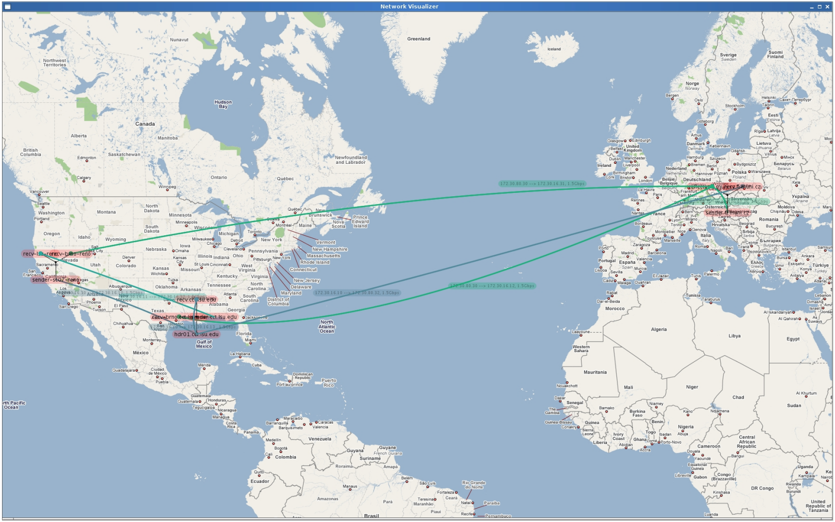
Prof. Thomas Sterling – lecture



Demonstrations

- iGrid 2005, 26. – 29. 9. 2005, Callt2, University of California, San Diego
  - HD Multipoint Conference
  - Interactive Remote Visualisation across the LONI and the National LambdaRail
- SC'05
- SC'06
- Glif 2007 – CoUniverse: Self-Organising Collaborative Environment
- SC'07 – CoUniverse demo
- RedStick2007
- I2 Fall 2008 member meeting – Dynamic Circuit Networking-enabled HD UltraGrid Videoconferencing

CoUniverse – topology



I2 Fall 2008 member meeting – I

I2 Fall 2008 member meeting – press release

The data for the UltraGrid demo will be distributed by application-level modular programmable UDP packet reflectors that have been developed over the past five years by CESNET and Laboratory of Advanced Networking Technologies. **This technology allows for independence on network-native multicast, while it is possible to process the data in per-user specific way**.
Both iHDTV and UltraGrid technologies are under active development by the research and education community. Through the iHD DevCore partnership, the community is currently investigating how to create interoperability between these platforms to enable more widespread adoption of uncompressed high-definition video technology.

Future work

- CoUniverse
  - Links planning, virtual network realisation
- Is virtualisation a solution of efficiency problem?
  - Return back to the lower network levels
- Next work on applications
  - Higher security level
  - Scalability on higher speed
  - Medical applications and their specific demands
- mobile collaborative environment
- Protocols with explicit latency compensation to support collaborative environments

Conclusion

- $1 : n$ data distribution – challenge for network protocols
- Native solution vs. virtual networks
- Active element is a key stone of virtual networks
    - From concept to implementation
- Ideas confirmed by applications
    - Administrations and reliability of use
    - Extreme traffic demands (demonstrations and routine traffic)
- Legacy of active networks is still alive.

Thanks to

- Employees and students from Laboratory of Advanced Network Technologies

- VZ Optical network for national research MŠM 6383917201
- VZ Large scale parallel and distributed systems MŠM 0021622419
- Ithanet–Electronic Infrastructures for Thalassemia Research Network (RI-2004-026539)
- MediGrid – methods and tools for use of Grids in biomedicine AV ČR T2 0209 0537

And special thanks to

- Petre Dini and Pascal Lorenz
- Program and Technical committees ICN Conferences
- And ICN for:
  - **ICN 2001 (First)**
    HLADKÁ, Eva - SALVET, Zdeněk. An Active Network Architecture: Distributed Computer or Transport Medium. Lecture Notes in Computer Science, Berlin Heidelberg New York : Springer, 2093, od s. 612-620. 2001.
  - **ICN 2004 (Third)**
    HLADKÁ, Eva - HOLUB, Petr - DENEMARK, Jiří. User Empowered Virtual Multicast for Multimedia Communication. Lecture Notes in Computer Science, Berlin Heidelberg New York : Springer, 3262. 2004.
  - **ICN 2005 (Fourth)**
    HOLUB, Petr - HLADKÁ, Eva - MATYSKA, Luděk. Scalability and Robustness of Virtual Multicast for Synchronous Multimedia Distribution. Lecture Notes in Computer Science, Germany, Springer Berlin / Heidelberg, Francie. ISSN 0302-9743, 2005, vol. 3421, no. -, s. 876-883.
  - **ICN 2009 (Eighth)**
    PROCHÁZKA, Michal - HOLUB, Petr - HLADKÁ, Eva. jSon: Network of Active Elements with Peer-to-Peer Control Plane. In The Eighth International Conference on Networks ICN 2009. Cancun, Mexico : IARIA, 2009. ISBN 978-0-7695-3552-4, 8 s. 1.3.2009, Cancun, Mexico.

Thank for your attention

questions?