



## **Programmability of the infrastructure**

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- Some history
- CHANGE
- Questions

- The idea has been around
  - Programmable Networks proposal and OPENSIG from Columbia and Cambridge University (1997)
  - Series of IWAN workshops
- Consequently the idea of active networks/networking
  - Eurescom Strategic Study P841 Impacts of Active Networks (1998)
  - Eurescom project P926 CASPIAN (1999)
- IEEE P1520 initiative

- Both focus on processing packets
- In active networks
  - Data packets carried code to be executed in routers
- In programmable networks
  - Code could be pre-loaded in routers
- Execution of code (both in active and programmable networks)
  - On custom router hardware or on commodity PC

- Processing unit = packet
  - Performance limited scalability
  - Hardware speed much-much slower than what is possible today
- Being packet centric
  - Most/ all routers had to be upgraded (sometimes the network stack in end hosts as well)
- Result:
  - Neither gained wide acceptance and failed to see deployment



Technology evolved and a lot of things have happened ...

- **Just started**
- **Objective: Explore the capabilities of OpenFlow to enable more innovation in the Internet**
  - Develop an architecture for flow processing platforms within the network
  - On-path and off-path flow processing
  - Basis for flexible deployment of innovative services
  - Architecture validation through application implementation

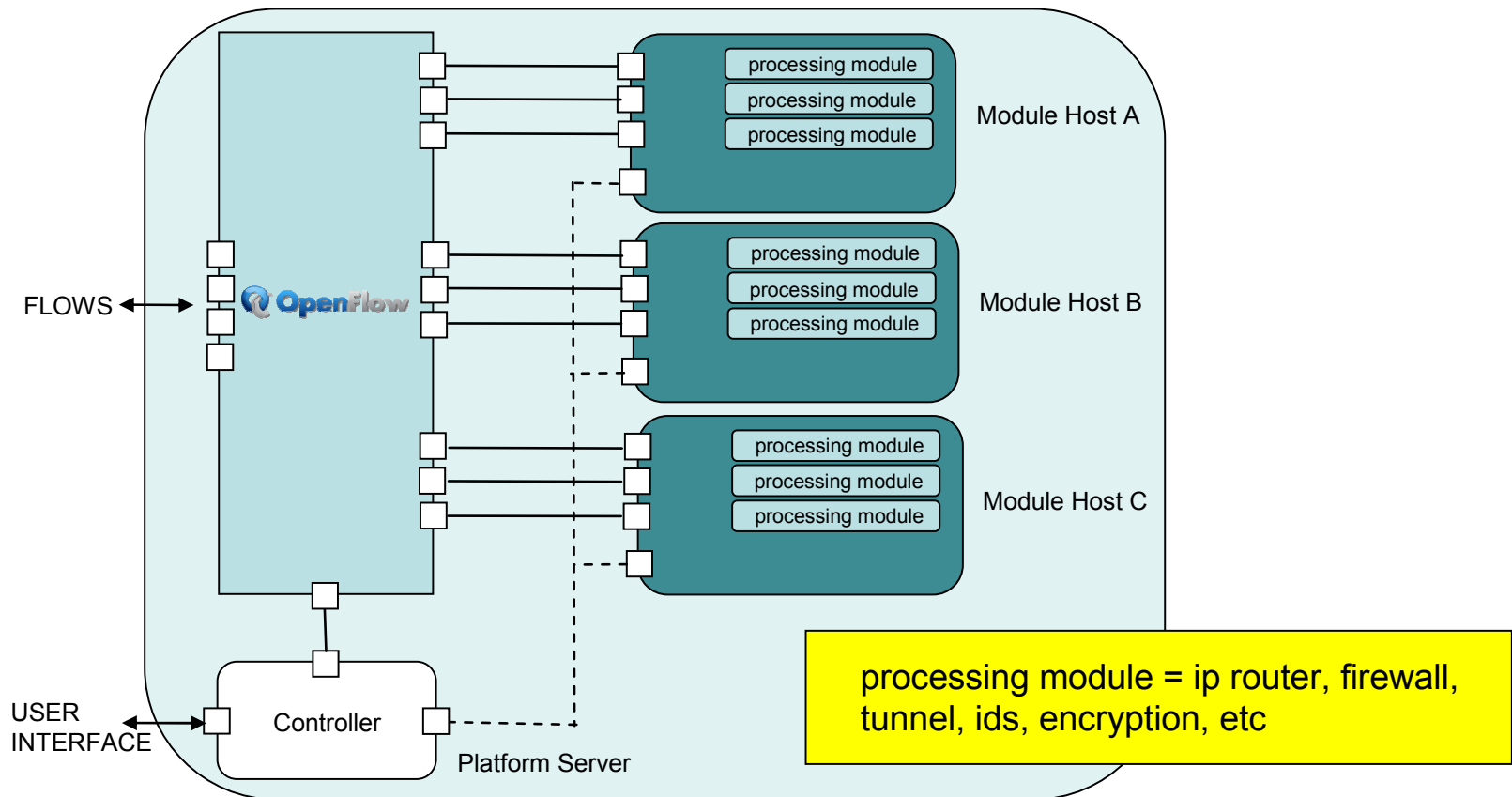
- **Size and scope of the Internet makes innovation at the network layer difficult**
- **Core network technologies hard to change, leading to ossification**
- **Even minor changes done through point solutions**
  - These embed knowledge in the network, optimizing today's applications at the expense of tomorrow's

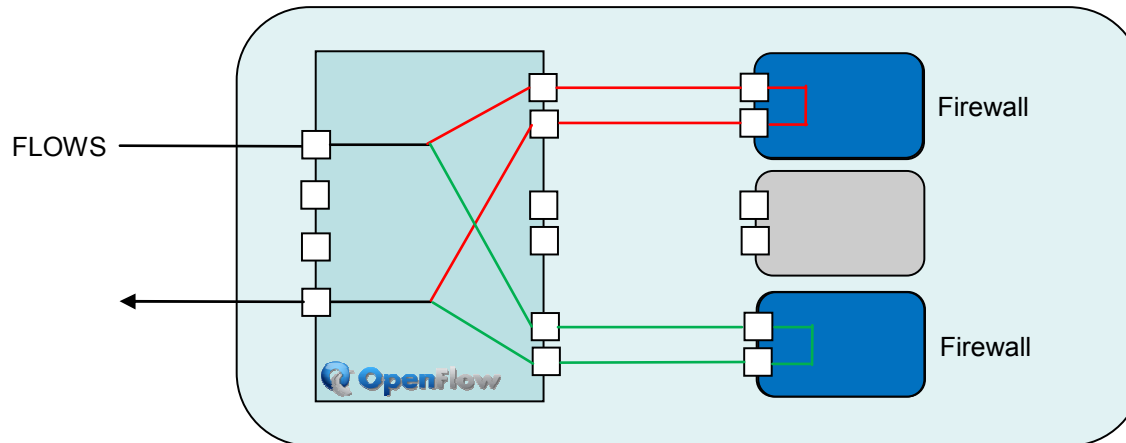
- **CHANGE brings the concept of virtualisation into the network realm**
  - Using virtualised, multi-tenant, dynamic networks to provide Network-as-a-Service (NaaS)
- **Industry players benefit from**
  - Innovative solutions for network systems based on flexible flow processing, paving the way for new market opportunities
  - Spin-off opportunities as well as increasing the patent portfolio in the area of flow processing
  - Enhancing the interoperability of CHANGE solutions by influencing standards related to the development of new products in the area of flow processing

- **CHANGE introduces the concept of a “flow processing platform” instantiated at critical points in the network**
  - Platform and interfaces are common but the processing performed is programmable
  - Programmability allows network to evolve and support rapidly-changing applications
  - Can be implemented using commodity hardware
- **Larger vision of the project is an architecture**
  - Combines multiple communicating flow processing platforms to provide innovative end-to-end services
  - Traffic flows can be processed at varying degrees of granularity, and application-specific virtual network overlays can be dynamically constructed without impacting other network services or traffic
  - Architecture will be validated on three-site testbed by implementing a set of innovative applications over it

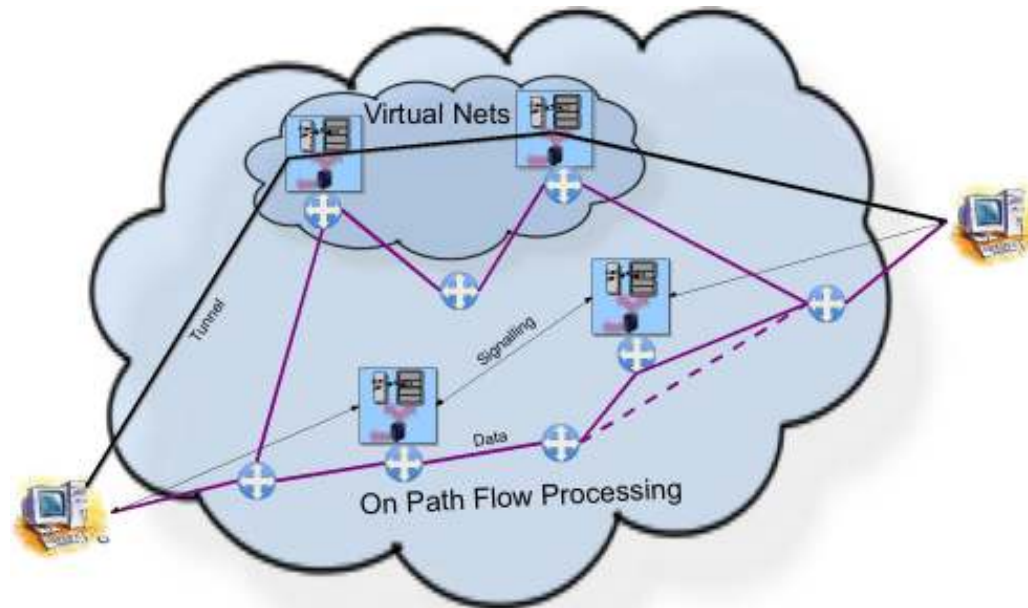
- **The platform consists of**

- Hardware: Openflow (OF) switches and x86 servers called module hosts
- Software: The platform's controller and the virtual machines called processing modules





- The controller splits flows (for instance based on IP prefix) to two different module hosts
- Flows are processed in parallel
- Flows are then merged back together at OpenFlow switch



## Virtual Nets

- Flows are classified and processed in one platform, then sent to another for further processing, and so on.
- These flow-level virtual networks give operators and application writers great flexibility in controlling how their traffic is forwarded and where it is processed.

## On-Path Flow Processing

- Traffic using IP forwarding needs to be processed as a flow at certain points in networks (e.g., firewalls, traffic shapers)
- Platforms can accommodate this, but even more benefit comes when inter-platform signaling allows for end-to-end processing

**In reality, these two concepts are likely to be used in combination**

- CHANGE has the same aim as programmable and active networks – a more flexible in-network processing
  - Difference is in the processing model and implementation approach used
- Processing unit = flows -> flexibility
  - Only traffic of interest is processed
- Only operation at packet level is classification
  - Benefiting from high-speed, cheap and commoditized hardware
- Concerning processing
  - High-performance multi-processor, multi-core systems
- Flow processing deployed only where needed, exploiting virtualisation
  - Assumptions and characteristics making the Internet successful are retained



**Poised to  
succeed!**

- Concept needs to be proved
  - Promises needs to be delivered on
- Interesting new development concerning the balance
  - Intelligence in the network vs. smartness at the edge

Website:

<http://www.change-project.eu>

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