Enabling Future Internet Architecture Research and Experimentation by Using Software Defined Networking

Prof. Flávio de Oliveira Silva

Faculty of Computing (FACOM)
Federal University of Uberlandia (UFU)

Brazil

Agenda

- Introduction
- SDN
- OpenFlow versions
- Future Internet Architecture Research and Experimentation
  - Experimental Facilities
  - Research Initiatives
- Concluding Remarks

Introduction

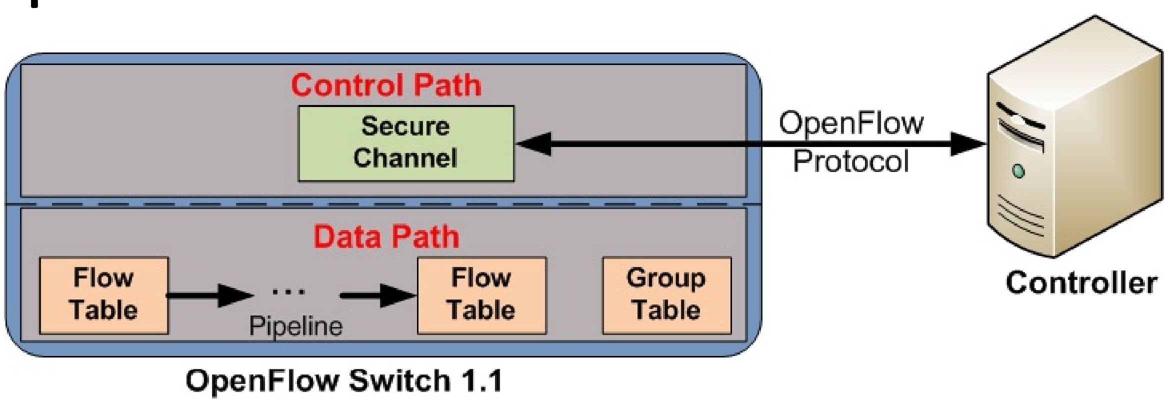
- Internet was designed in totally different context, far from of what he have today
- New applications define a new set of requirements that are not satisfied by the current Internet
- Researchers are engaged in designing a new Internet using a clean slate approach
- SDN, current materialized in OpenFlow enable researchers to innovate in computer networks
- SDN represents an extraordinary opportunity to rethink computer networks

SDN

- Deployment and experimentation of new network architectures is really difficult even at a laboratory inside a campus
- Researchers are *locked* in their networks
- SDN decouples the software that controls the network elements from the hardware
- SDN enables the deployment and experimentation of new network architectures

OpenFlow

- SDN, currently, is materialized in OpenFlow
- OpenFlow separates the data plane from the control plane of switches



OpenFlow Versions

Version	Release Date	Flow Tables	Number of Match Fields	Extensible Match Support	Availability	Mandatory Actions	Optional Actions	Support
1.0	12/31/2009	1	12	No	Software and Hardware	Forward, Drop	Forward[1], Enqueue, Modify-Field	Ethernet, IP, TCP
1.1	02/28/2011	Pipeline	15	No	Software	Output, Drop, Group	Output[1], Set-Queue, Push-Tag/Pop-Tag, Set-Field	1.0 protocols + MPLS
1.2	12/05/2011	Pipeline	36	Yes	Software[2]	Output, Drop, Group	Set-Queue, Push-Tag/Pop-Tag, Set-Field, Change-TTL	1.1 protocols + IPv6
1.3	04/16/2012	Pipeline	40	Yes	Not yet	Output, Drop, Group	Set-Queue, Push-Tag/Pop-Tag, Set-Field, Change-TTL	1.2 protocols + IPv6 Extension Headers

1 - The forward (output) to some types of defined ports is optional.
2 - Recent released versions.

Future Internet Architecture Research and Experimentation

Experimental Facilities

- Current Internet development was based on experimental research using the ARPANET
- OpenFlow can enable an experimentally oriented research based on large test beds
- Opportunity to use appropriate scales that are required to a new Internet architecture
- OpenFLow based Facilities
  - USA: GENI
  - EUROPE: OFELIA
  - BRAZIL: FIBRE and OFELIA
    - Intercontinental OpenFlow based infrastructure

Future Internet Architecture Research and Experimentation

Research Initiatives

- Some research groups are focusing the use of SDN and OpenFlow
- Research is related with new network architectures that addresses future Internet requirements.
- Initiatives described here have in common:
  - Vision of a new protocol stack and the use of new naming and addressing schemes
  - Use of OpenFlow for experimentation

Research Initiatives

- USA
  - NSF FIA (Future Internet Architecture) Program
  - Aims to design and evaluate new Internet architectures.
  - Five granted projects
  - Two of them, are considering at this moment the use of OpenFlow (MobilityFirst and XIA - eXpressive Internet Architecture)
- Europe
  - Several projects under FP7 program regarding Future Networks
  - COntent NETwork (CONET)
    - Under the context of OFELIA
- Brasil
  - Entity Title Architecture (ETArch)
  - Lead by our research group and other Brazilian Institutions
  - Network architecture that naturally fits on the SDN approach

Research Initiatives MobilityFirst

- http://mobilityfirst.winlab.rutgers.edu/
- Mobility is a fundamental design goal regarding future Internet
- Key aspects
  - New naming scheme based on a Globally Unique Identifier (GUID) mapped to a flat Network Address (NA)
  - Generalized Storage-Aware Routing (GSTAR) uses an adaptable mechanism that handles varying link quality and disconnection
  - Global Name Resolution Service (GNRS), distributed over the routers, that is responsible for mapping the GUID to a network address
- Experimentation
  - Project has three phases for prototyping and evaluation
  - First phase assumed prototyping using a software router based on Click
  - Moving to an OpenFlow enabled prototype

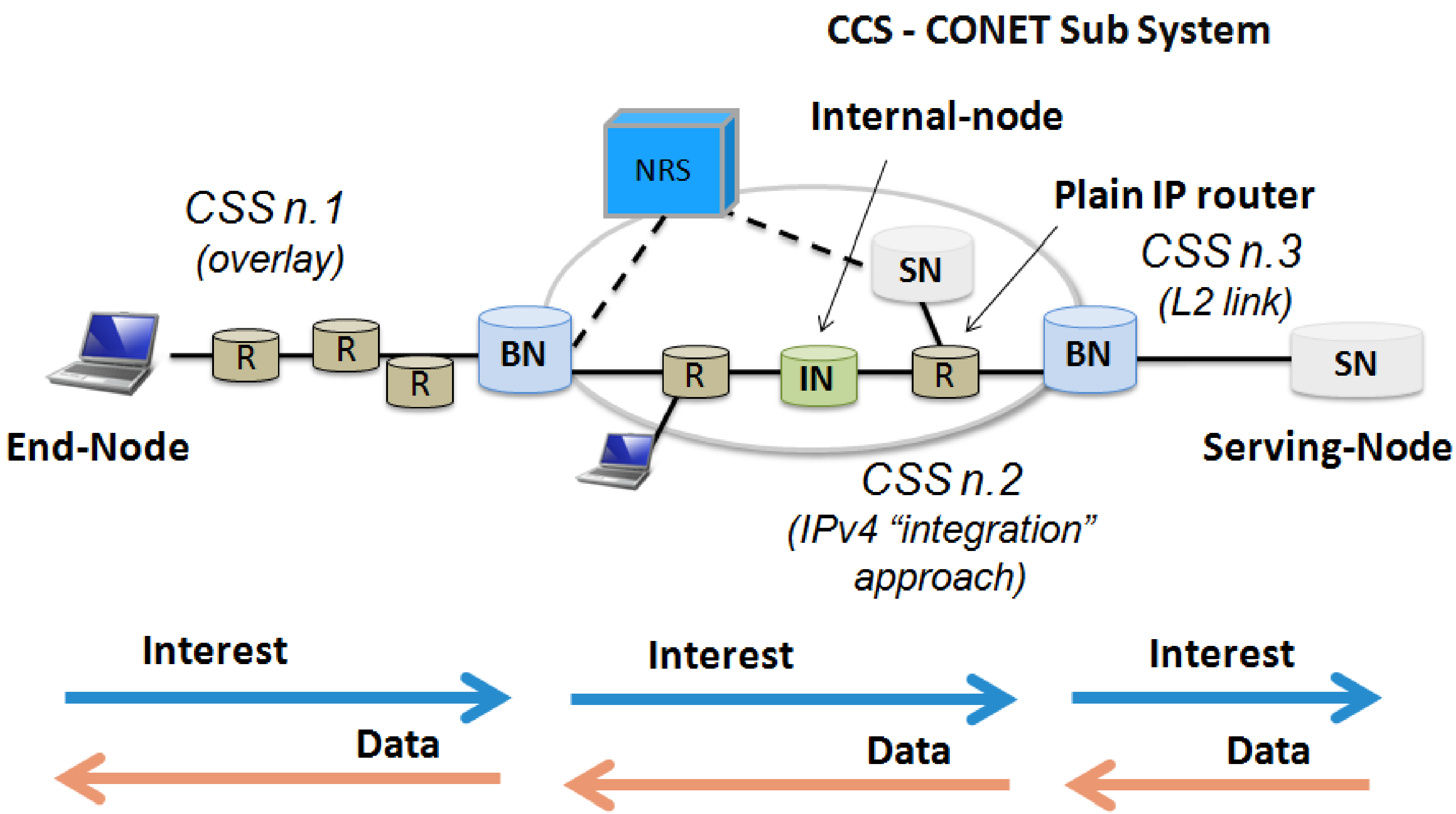
Research Initiatives
XIA - eXpressive Internet Architecture

- http://www.cs.cmu.edu/~xia/
- Clean slate, trustworthy and evolvable network
- Key aspects
  - First class citizen at the architecture is called Principal (content, a service, a host, a user)
  - Naming scheme based on the a Principal identification that is generated by hashing a public key
  - Addressing scheme based on a Directed Acyclic Graph (DAG) that contain the Principal's identifier at each hop
- Experimentation
  - The first prototype of XIA architecture uses a XIA router based on Click
  - They will implement XIA forwarding engine using OpenFlow
  - Expectation that the OpenFlow based implementation will be faster than the current prototype
  - This implementation will allow to scale current experiments, performing more realistic evaluation of the architecture over GENI

Research Initiatives
CONET (COntent NETwork)

- http://netgroup.uniroma2.it/twiki/bin/view/Netgroup/CoNet
- Based on the content-centric paradigm where content is the first class citizen
- Key aspects
  - Network architecture has a layer capable of providing the users access to Named Resources (Content or Services)
  - Network consists of several CONET nodes interconnected by CONET Sub Systems (CSS)
  - Type of Nodes: End Nodes (EN), Serving Nodes (SN), Border Nodes (BN), Internal Nodes (IN) and Name Routing System Nodes (NRS)
  - Nodes exchange CONET Information Units (CIU) that can express an interest on some named-data or chunks of this named-data
  - Two different approaches regarding the packet format: one is based on a clean slate packet and other that uses IPv4 or IPv6 options to carry CONET related information
- Experimentation
  - CSS deployed under OFELIA (OpenFlow 1.0 based network) by mapping the content name into TCP source and destination ports
  - Flow Tables are modified in a reactive mode to get general processing rules and in proactive mode in the event of new contents cached

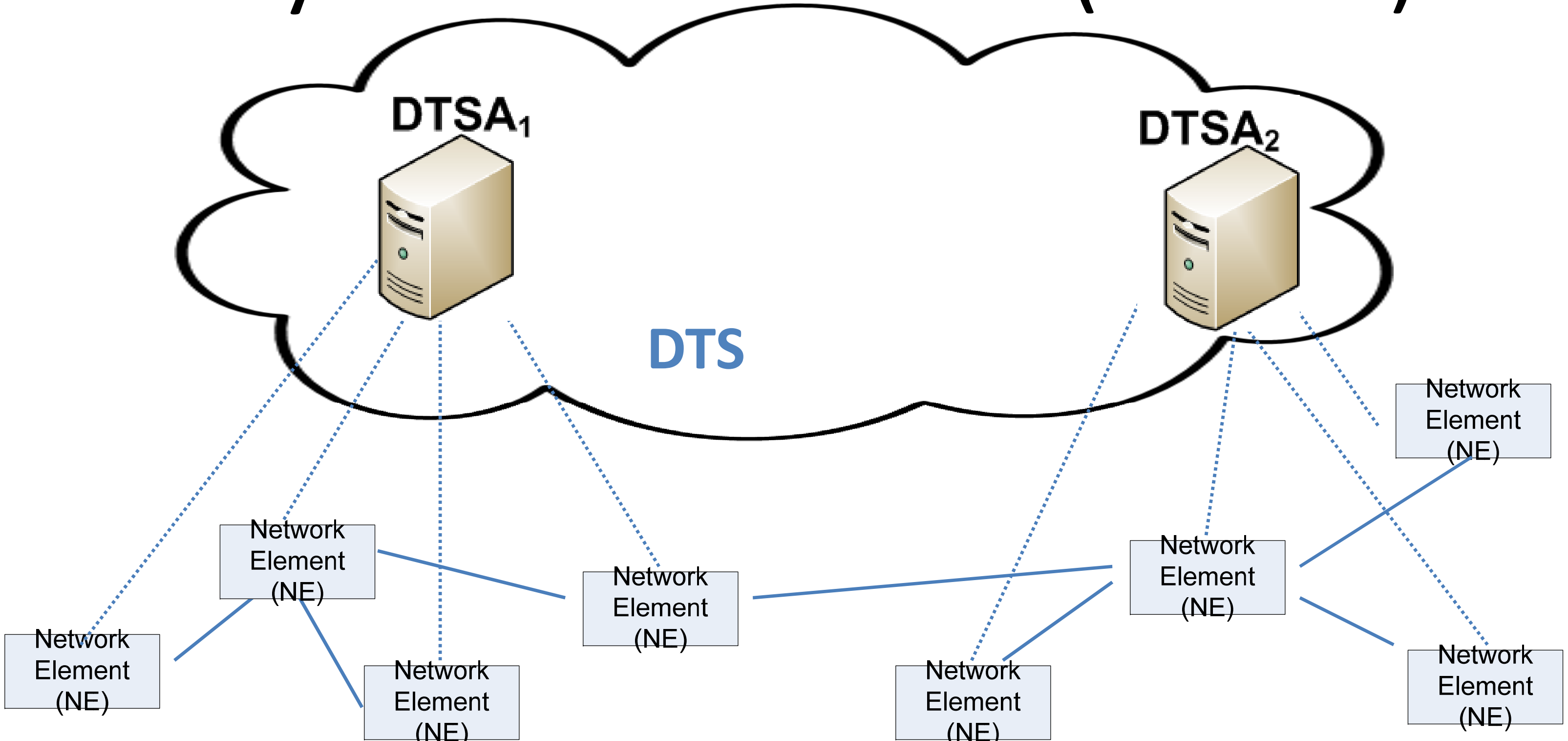
Research Initiatives
CONET (COntent NETwork)



Research Initiatives
Entity Tile Architecture (ETArch)

- http://www.mehar.facom.ufu.br/
- Entity (content; sensor; a smart phone; an application) is the first class citizen.
- It has a Title and communication requirements and capacities which can be semantically understood from top to bottom layers
- Key aspects
  - Based on a new naming and addressing schema, called workspace, where Multicast and Mobility are seamlessly provided
  - Architecture components: Domain Title Service (DTS), DTS Agent (DTSA), OpenFlow based substrate
  - Title is a topology independent designation to ensure an unambiguous identification of an entity
  - DTS deals with all the control aspects of the network
- Experimentation
  - OpenFlow was our first choice for experimentation
  - Flow table handles the information to produce the workspace materialization (Ethernet source and destination addresses plus the VLAN are mapped to the workspace Title)
  - First prototype of ETArch was deployed and experimented at OFELIA
  - Research agenda now considers integration with IEEE 802.21 implementation to support the vertical handover optimization in the presence of multiple access networks

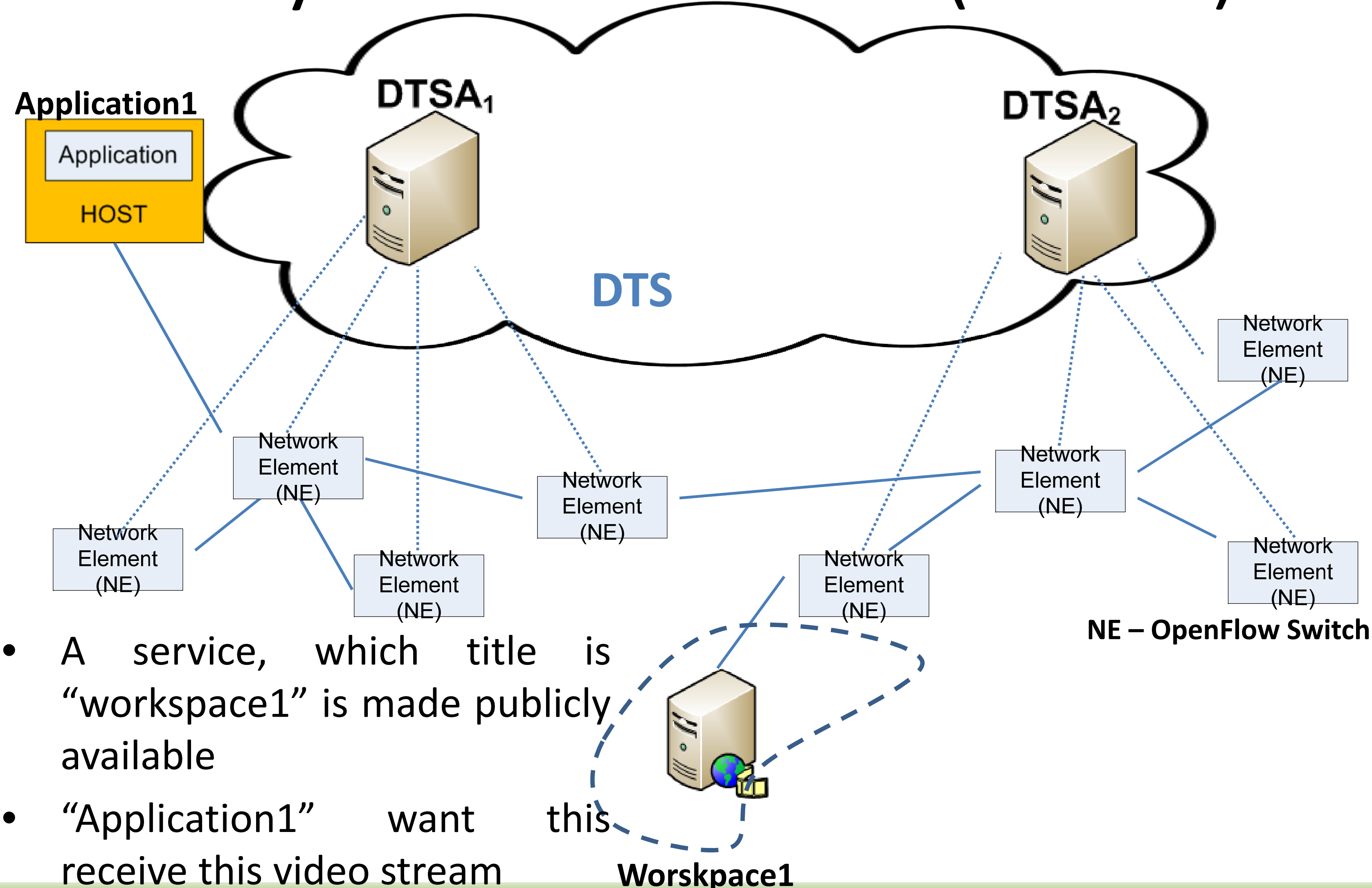
Research Initiatives
Entity Tile Architecture (ETArch)



NE – OpenFlow Switch

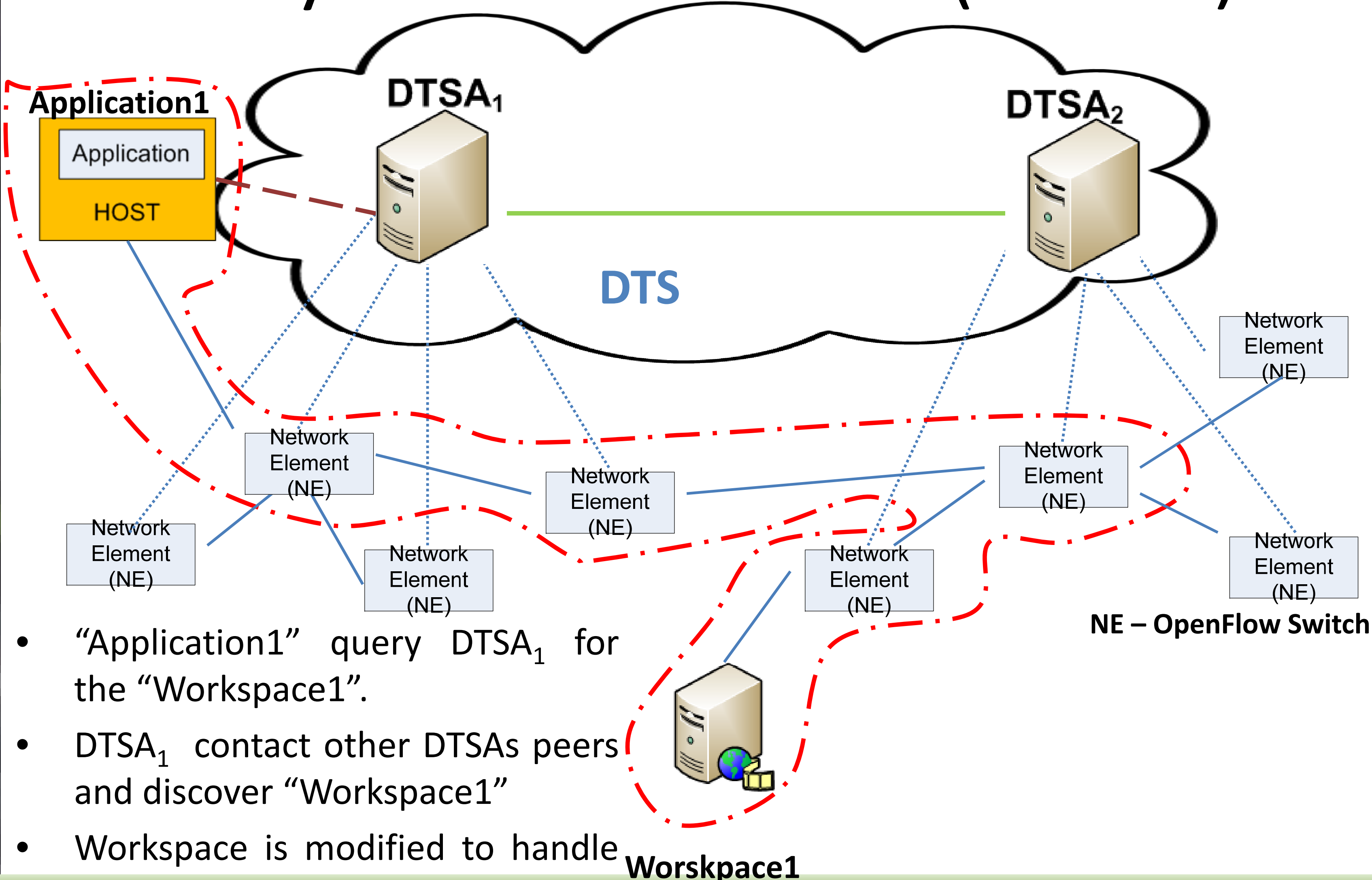
- Basic infrastructure
- DTS composed of DTSAs
- DTSAs contains an OpenFlow Controller

Research Initiatives
Entity Tile Architecture (ETArch)



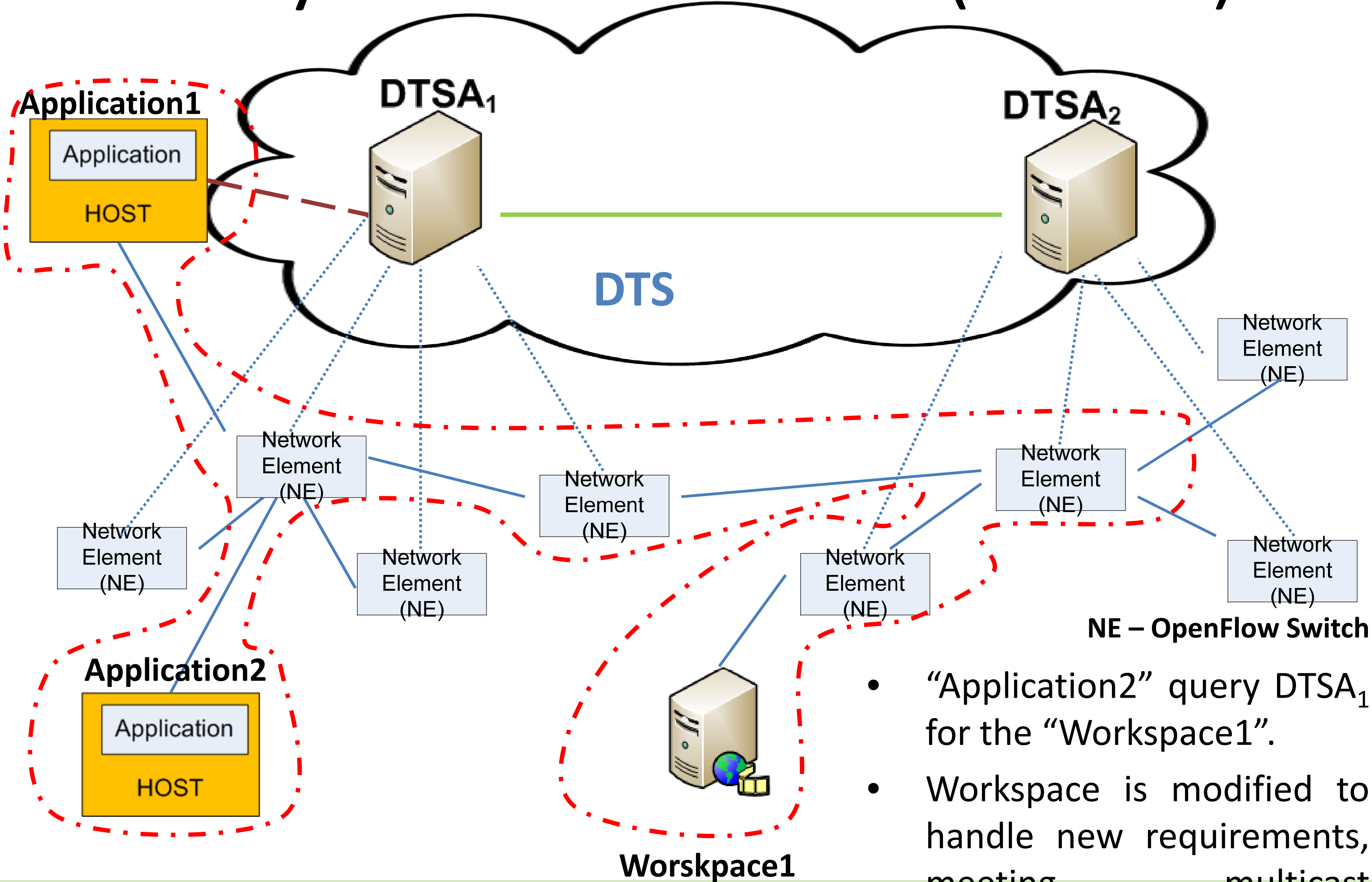
- A service, which title is "workspace1" is made publicly available
- "Application1" want this receive this video stream

Research Initiatives
Entity Tile Architecture (ETArch)



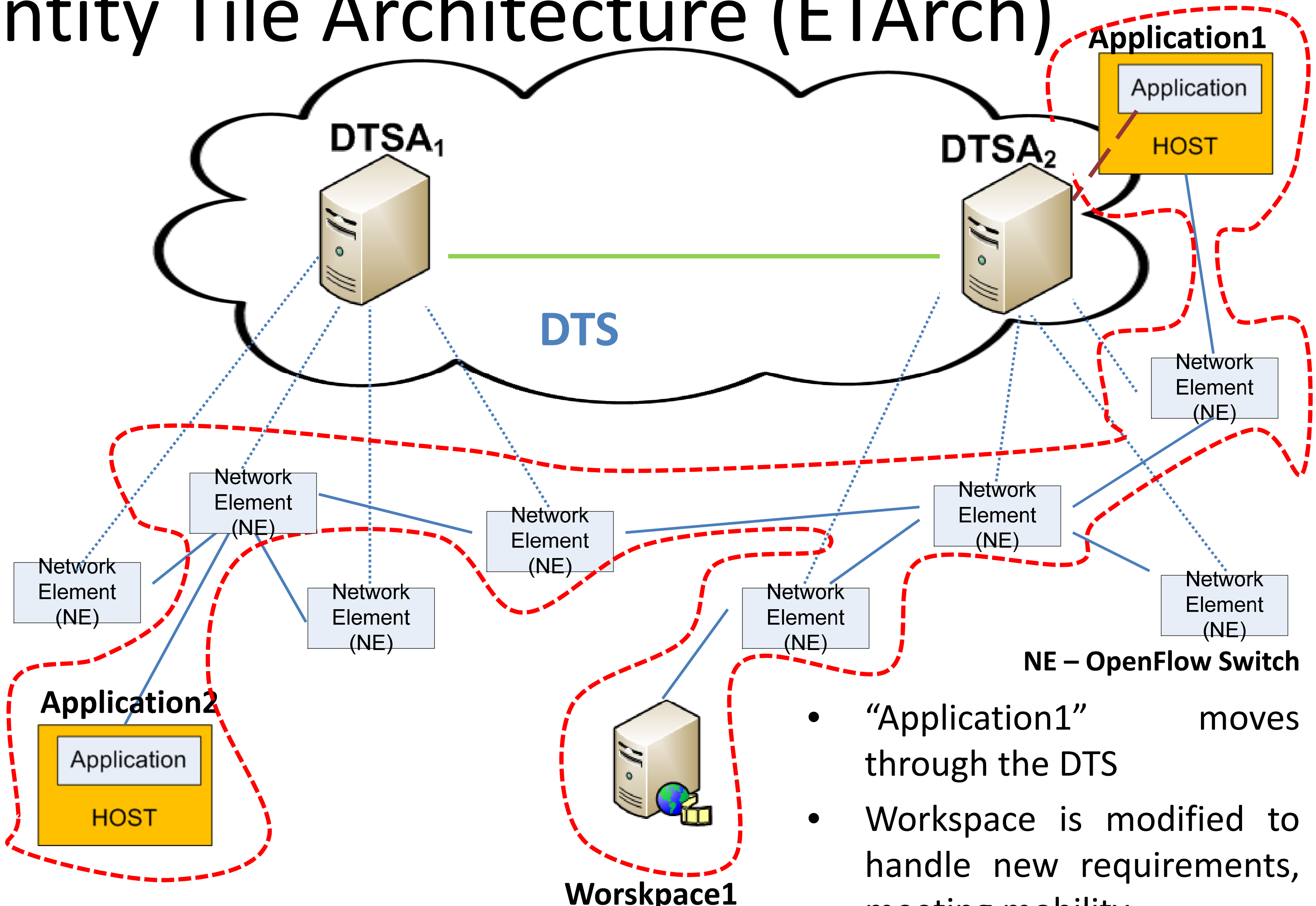
- "Application1" query $DTSA_1$ for the "Workspace1".
- $DTSA_1$ contact other DTSAs peers and discover "Workspace1"
- Workspace is modified to handle new requirements

Research Initiatives
Entity Tile Architecture (ETArch)



- “Application2” query DTSA$_1$ for the “Workspace1”.
- Workspace is modified to handle new requirements, meeting multicast aggregation

Research Initiatives
Entity Tile Architecture (ETArch)



- "Application1" moves through the DTS
- Workspace is modified to handle new requirements, meeting mobility

Concluding Remarks

- Considering a new set of requirements Internet architecture must be reviewed
- Deployment and experimentation of new network architectures is difficult even at a laboratory inside a campus
- At different continents, wide OpenFlow enabled infrastructures are available to research groups enabling an experimental evolution of future Internet
- By using OpenFlow version 1.0, different research groups, at different stages, are experiment new network architectures
- Semantic of each architecture must be mapped to the 1.0 match fields
- OXM, recently available at software, is suitable for a new network architectures
- OpenFlow, the deployed vision of SDN, represents today the most viable alternative to experiment, at scale, new network architectures