Mondial Entities Horizontally Addressed by Requirements (MEHAR) Program

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Agenda

- About UFU and FACOM
- Future Internet Architecture - Overiew
- How we get here: a small history
- MEHAR Program
- MEHAR Past and Current Projects
- Entity Title Architecture (ETArch)
- Next Research Steps
- Concluding Remarks

About the Federal University of Uberlandia

- **Minas Gerais** is a state at the southeast region of Brazil
- Federal University of Uberlândia (UFU) is Higher Education Institution (HEI) funded by the Federal government of Brazil
- UFU has 1.600 professors and 32.000 students
- UFU offers 72 different undergraduate courses, 30 Masters of Science Courses, 20 Ph.D. Courses, distributed in different areas of knowledge

About Faculty of Computing Federal University of Uberlandia

- School started at 1988
- 63 full professors
- Education
  - Graduate courses (Bachelor Degree)
    - Computer Sciences
    - Information Systems
    - About 1000 students
  - Post Graduation
    - 85 students
    - Master's Science Program (Started at 2000)
    - PhD Program

Future Internet Research and Innovation Lab at UFU

- Research and Development focused on the Future Internet
  - OFELIA Island
  - FIBRE Island (under deployment)
  - FI-WARE Node
- Experimentally-driven research (FIRE)

OFELIA ISLAND (fp7-ofelia.eu)

FIBRE ISLAND (fibre-ict.eu)

FI-WARE Node (fi-ware.org)

Faculty of Computing
Federal University of Uberlândia

The Network must be reviewed

- Advances
  - Software
  - Hardware
  - Communications
- Current scenario
  - Mobile devices
    - High resolution cameras; Different sensors; Multiple wireless interfaces; Connected to clouds of servers; Broadband access networks
  - New services and applications emerged
  - Networks are more complex to manage
- The Internet architecture is not able to satisfy the new applications requirements
- Future Scenario
  - Future Internet can enable new services and applications

Future Internet Architecture

- Research Scenario
  - USA
    - Five projects are currently being funded by NSF under the FIA initiative: MobilityFirst, XIA (eXpressive Internet Architecture), Named Data Networking, Nebula and ChoiceNet
    - Previously (2010) in the context of FIND (http://www.nets-find.net/), 49 projects where funded
  - EU
    - A myriad of projects, funded by FP7, grouped under the FIA (Future Internet Assembly) has a vision regarding the Future Internet
    - Usually each project focus on some aspects the network
    - FIArch group whose objective is to define a common set of architectural design principles and a reference architecture of the Future Internet
  - Brazil
    - FIBRE (Focus on Test Bed for Research and Experimentation)
    - Federal University of Uberlandia and University of São Paulo (Future Internet Architecture)

How we get here: a small history

- Since 2006 a professor and some students started to thing about a new type of networking…
- At December, 2009 (NTMS between 20th and 23rd) a called “Horizontal Address Ontology in Internet Architecture” was published

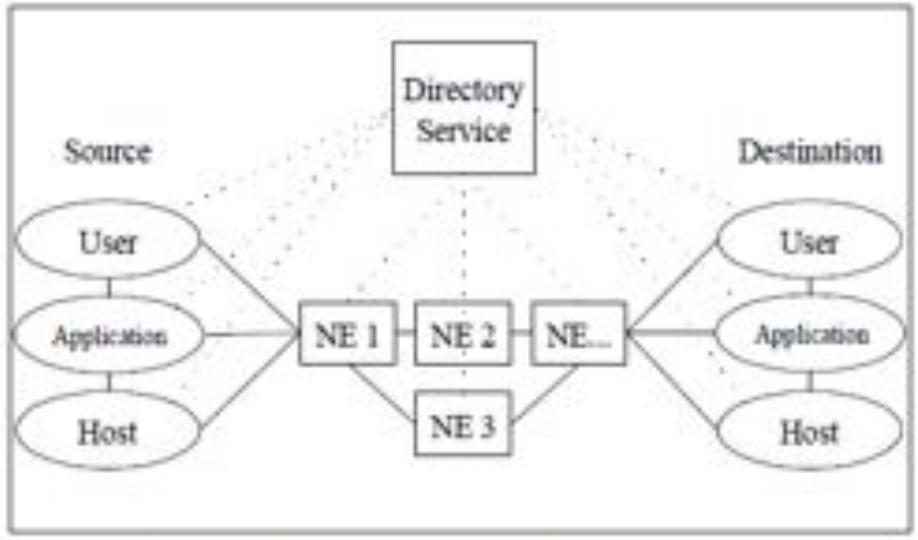


Figure 6. Horizontal Addressing by Directory Service.

- OpenFlow Switch Specification version 1.0.0 (Wire Protocol 0x01) was released at December 31, 2009

How we get here: a small history (2)

- How to bring these ideas to life?
  - By July, 2010 we found OpenFlow and realized that OpenFlow (and SDN) could be used for this purpose
- We concluded that our vision of the network matches naturally with SDN abstractions
- Since there we get deeper into OpenFlow and SDN
- By 2011 we participate in a contest organized by MyFire EU project and we had a proposal selected by experimentation at OFELIA Testbed
- By 2012 we had a proposal accepted at the Second OFELIA Open Call, called EDOBRA (Extending and Deploying OFELIA in Brazil) in partnership with USP (University of São Paulo) and the Instituto de Telecomunições (IT) from Aveiro, Portugal
- At 2013 we presented ETArch (Entity Title Architecture), a clean slate network architecture built on top of OpenFlow
- One of the results our work during EDOBRA (Openflow + IEEE 802.21) was selected as an Academic demo for ONS2014

MEHAR Program

- MEHAR (Mondial Entities Horizontally Addressed by Requirements) Program consists of a set of related Projects
- Its basic goal is to evolve communication networks in order to make them capable of providing the communication requirements of users and applications with a smarter and efficient use of resources

MEHAR Vision

- Define, design, and deploy a communication paradigm that can bring to the core of the network intelligence that would enable an autonomic behavior capable of satisfy all requirements provided by an entity with a smarter and efficient use of resources

MEHAR Assumptions

- Mondial Entities
  - An entity is something with communication requirements
  - Entities can be anywhere
  - The set of peer entities responsible for the communication is flexible and its variable over time
  - The variation is caused by a number of factors and can be driven by satisfying new requirements based on a smarter use of resources
- Horizontally Addressed
  - Entities can be horizontally addressed, considering broader view of the address concept regarding location and context
- Requirements
  - Network might be capable of handling user and application requirements over time, which will driven communication

MEHAR Objectives

- Define a new approach for network addressing, capable of use the term “address” in a higher view comprising location and communication requirements based on the entity's context
- Design an intelligent protocol architecture, capable of recognize entity’s context and based on this knowledge implement only the network aspects required by the communication such as: routing, QoS, QoE, reliability, security, flow and error control
- Elaborate a cross layer ontology capable of providing to this protocol architecture a richer semantic capacity in order to guarantee that an entity can express its requirements and communicate them in a horizontal and vertical view
- Deploy the research results and conduct them based on experimentation using different physical infrastructures

MEHAR Objectives

- Collaborate with future Internet research providing an architecture that could support different approaches such as: Content Centric, User Centric, Service Centric, Internet of Things (IoT)
- Based on a smarter communication, with a better use of resources, help to construct smarter cities and societies
- Foster innovation, providing a new communication paradigm capable of handling a totally new group of services

Research, Funding and Industry Partners

- Instituto de Telecomunicações Aveiro (Portugal)
- Polytechnic School, University of São Paulo
- Federal University of Rio Grande do Norte (UFRN)
- RNP (Brazilian NREN)
- OFELIA
- FIBRE
- FI-WARE

- DATACOM
- FP7
- CAPES
- CNPq
- FAPEMIG

- ALGAR TELECOM
- DATACOM

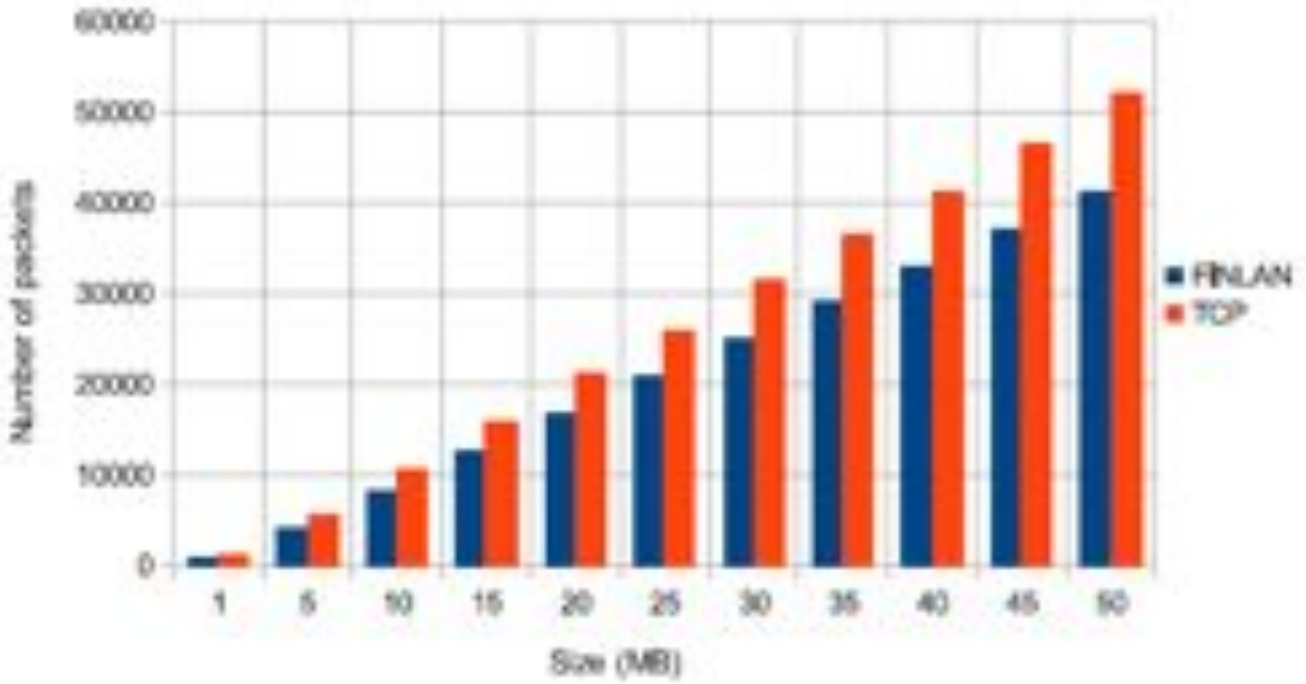
Resources
People engaged on the program

- Federal University of Uberlandia (UFU)
  - Professors: Pedro Frosi Rosa; João Henrique de Souza Pereira; Luiz Cláudio Theodoro and Flávio de Oliveira Silva
  - 25 students (undergraduate and graduate)
- Polythenic School, University of São Paulo (USP)
  - Prof. Sergio Takeo Kofuji
  - 2 Ph.D. Students
- Instituto de Telecomunicações Aveiro (University of Aveiro, Portugal)
  - Prof. Rui Aguiar and Daniel Corujo
  - 1 Ph.D. Student
- Federal University of Rio Grande do Norte (UFRN)
  - Prof. Augusto José Venâncio Neto
  - 4 M.Sc.students
- ALGAR TELECOM
  - João Henrique de Souza Pereira and Luiz Cláudio Theodoro
  - 15 associates
- And counting…

MEHAR Projects

- Past projects
  - FINLAN
  - EDOBRA
- At this moment the program has the active projects
  - ETArch – Entity Title Architecture
  - SMART – **S**upport of **M**obile Sessions with High Tr**a**nspo**rt** Network Resource Demand
  - CREDENCE - **C**arrier-grade softwa**RE** **DE**fined **N**etworking **C**ontrol **E**nvironment
  - ETArch PILOT
  - Future Internet Innovation Laboratories (FII-LABS)
- Future Steps

Fast Integration of Network Layers (FINLAN)



DE OLIVEIRA SILVA, F. et al. Semantically enriched services to understand the need of entities. In: ÁLVAREZ, F. et al. (Eds.). **The Future Internet**. Berlin, Heidelberg: Springer-Verlag, 2012. p. 142–153.

Fast Integration of Network Layers (FINLAN)

Size	FINLAN	TCP	Reduction (%)
1 MB	847	1168	37,9%
5 MB	4174	5594	34,0%
10 MB	8140	10631	30,6%
15 MB	12566	15733	25,2%
20 MB	16722	21060	25,9%
25 MB	20920	25277	25,6%
30 MB	25017	31423	25,6%
35 MB	29089	36495	25,5%
40 MB	32786	41143	25,5%
45 MB	37070	46585	25,7%
50 MB	41207	52067	26,4%

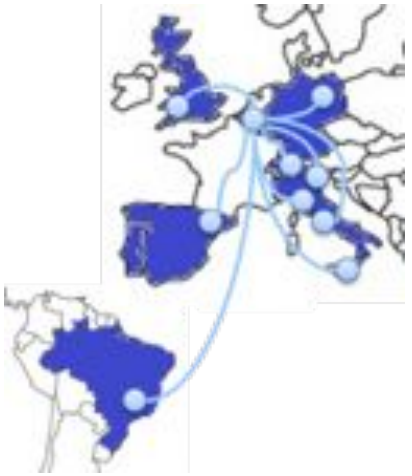
(b) Percentual reduction

Fig. 5. FINLAN and TCP traffic comparison

DE OLIVEIRA SILVA, F. et al. Semantically enriched services to understand the need of entities. In: ÁLVAREZ, F. et al. (Eds.). **The Future Internet**. Berlin, Heidelberg: Springer-Verlag, 2012. p. 142–153.

Extending and Depoying Ofelia in BRAzil (EDOBRA)

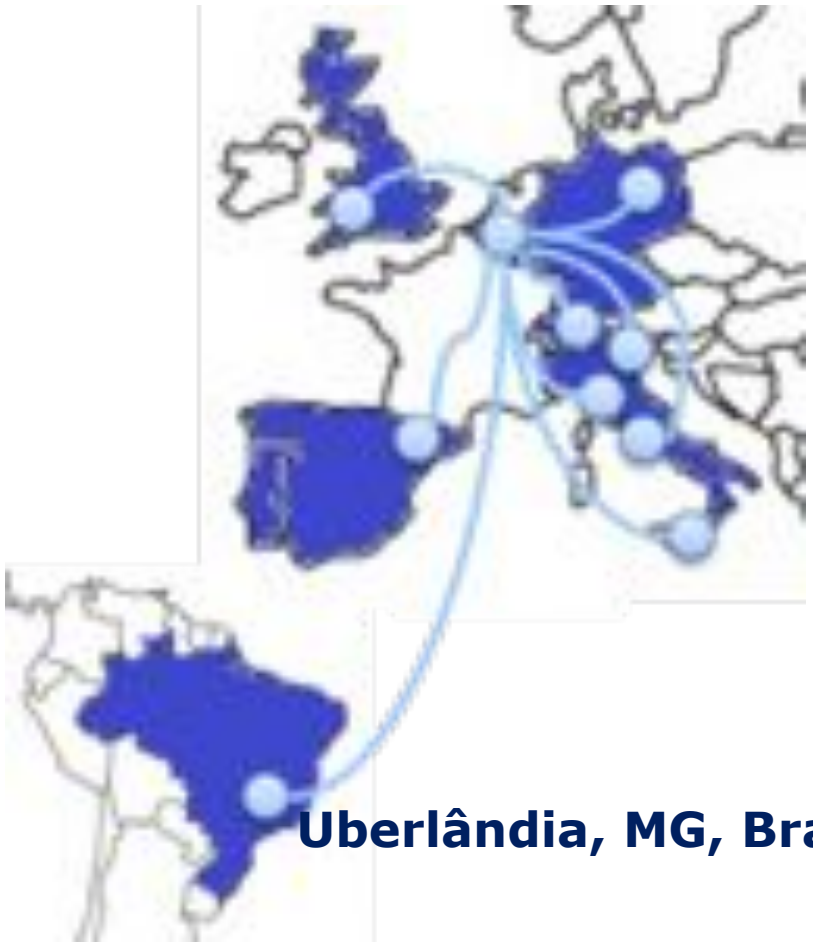
- OFELIA Island at UFU
  - Federated with OFELIA European islands
  - Focus on new network architectures that consider aspects such as multicast and mobility in the presence of heterogeneous networks
  - Based on:
    - L2/L3 switches (DATACOM);
    - NetFPGA switches
    - EDOBRA Switches
      - OpenWrt + OpenFlow + ODTONE



http://www.fp7-ofelia.eu/ofelia-facility-and-islands/

OFELIA after EDOBRA

- http://www.fp7-ofelia.eu/ofelia-facility-and-islands/



Uberlândia, MG, Brazil

Entity Title Architecture (ETArch)

- A clean slate Future Internet architecture
- Applies new naming and addressing schemes based on the Title
- Title is a topology independent designation that ensures an unambiguous identification of an entity
- An Entity has communication requirements and capabilities than can be semantically understood from top to bottom layers;
- Communication based on the Workspace, a channel gathers multiple entities;
- Domain Title Service (DTS) deals with all control aspects of the network and is composed by interconnected Domain Title Service Agents (DTSAs);
- DTSA maintain information about registered entities and the workspaces that they are subscribed to, aiming to configure the network devices to implement the workspaces and to allow data to reach every subscribed entity;
- Internetworking inside the DTS by using the DTSAs;

ETArch Concepts

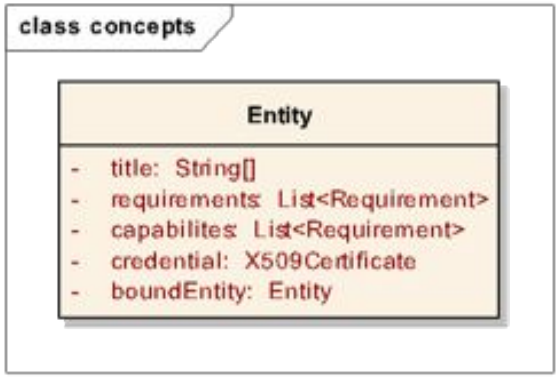
- Entity
- Title
- Workspace
- Domain Title Service (DTS)

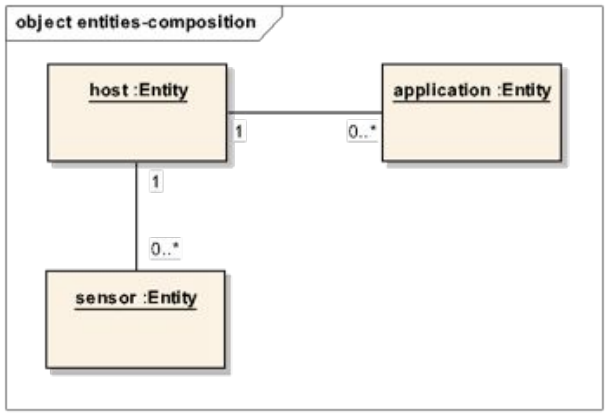
Entity

- First class citizen
- Has communication requirements and capabilities that can be semantically understood from top to bottom layers of the architecture
- Some examples of entities: an application, a service, an user, a sensor, a host, a smartphone, a process
- An Entity has at least one Title and a location that can be variable over time
- This approach enables the architecture to satisfy different requirements sets provided by different visions of the Internet such as service-centric, user-centric and the Internet of the Things (IoT) while handling the current host-centric Internet

Entity

- An entity has the following properties:
  - title, requirements, capabilities, credential, boundEntity (optional)
- An entity such as an application or sensor can be bound to another one such as host (computer, tablet, smartphone)
  - This entity can inherit any property of the one it is bound, except for the title
  - The title can be the title of the bound entity plus a random generated suffix





Workspace

- The workspace is this channel able to gather communicating multiple participants.
- It can be viewed as a logical bus able to link multiple entity instances.
- Its behavior is similar to a multicast group where the data is sent once by a source to the workspace and is received by all the others entities, thus making an efficient use of the physical layer.
- A workspace is created when an entity needs to communicate with another entity for a specific purpose, such as video-conferencing or file sharing.
- To create a workspace, an entity requests its creation to the local DTSA and must specify the requirements it has and capabilities it may offer in conversing with other entities into that workspace.
  - For example, the entity may require secrecy and delivery guarantees from its peers, while also offering a maximum bandwidth value.
- Control plane protocols are responsible for the creation, maintenance and disposal of workspaces.

Title

- An unambiguous identification of an entity
- Topology independent designation
- Entity has a one to many relationship to titles
- A set of titles is grouped in a namespace
- The namespace is a unique identification space and it is responsible for adding an initial meaning to the associated title
- Namespaces could be granted by an organization such as the Internet Corporation for Assigned Names and Numbers (ICANN)
- Titles will be managed by specific name servers dedicated to every namespace
- A title is represented as: **namespace::entity-identification**
- The title associated with entities at the Application layer usually is expressed by using a human readable format such as Unicode characters.
- In turn, the title associated with entities at the communication layer can be expressed by using a bit string, for instance

Workspace

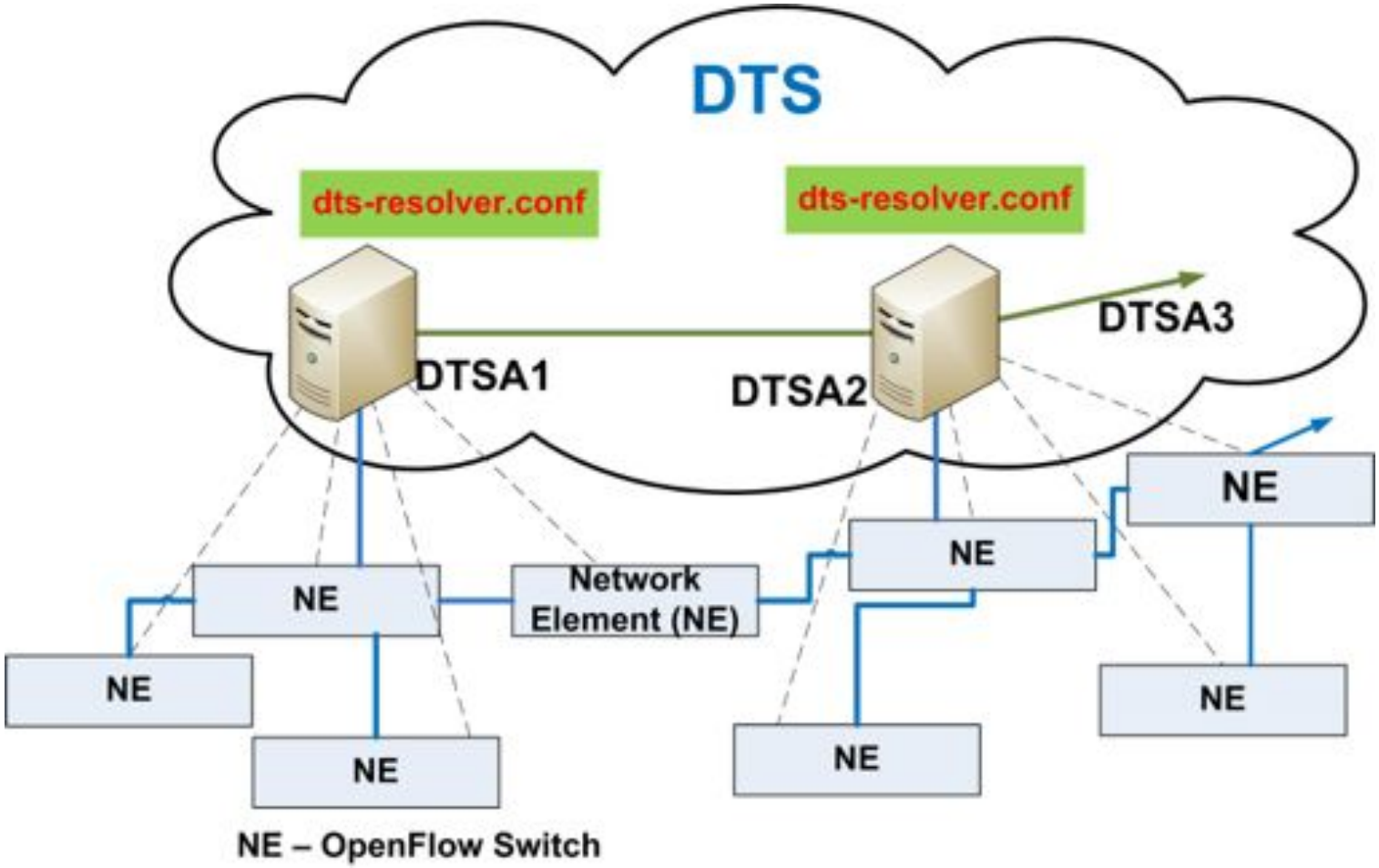
- A new entity, willing to take part in the conversation, can be attached to an existing workspace
- In such event, the DTSA is the responsible to reconfigure the network elements that it controls to handle the communication.
- In the presence of a failure of a network element, the DTSA is capable to accomplish the workspace reconfiguration in order to maintain the communication
- When a entity moves from one point of attachment to another, the workspace is adapted, thus, supporting the mobility of the entities over the network.
- The workspace could be spanned through several DTSAs, being that, every DTSA is responsible for the monitoring and control of the network elements supporting this workspace.

Domain Title Service

- The Domain Title Service (DTS) deals with all the control aspects of the network
  - Represents the “Control Path”, so all the data transmitted is related to control primitive
- Handles communication requirements over time
- Is a distributed system over the network elements and is responsible for maintaining information regarding all the entities under its influence, such as the associated titles, the communication requirements and capabilities over time, the connection setup and their maintaining.
- The DTS is composed by a set of interconnected Domain Title Service Agent (DTSA).
- Network elements are switches that are controlled by the DTSA and whose behavior can be modified on the fly.
- The design of the DTSA has a match with Software Defined Networking (SDN) abstractions, that currently is materialized by OpenFlow
- To communicate, each entity must, initially, register at the DTS, through the DTSA it is linked in that moment

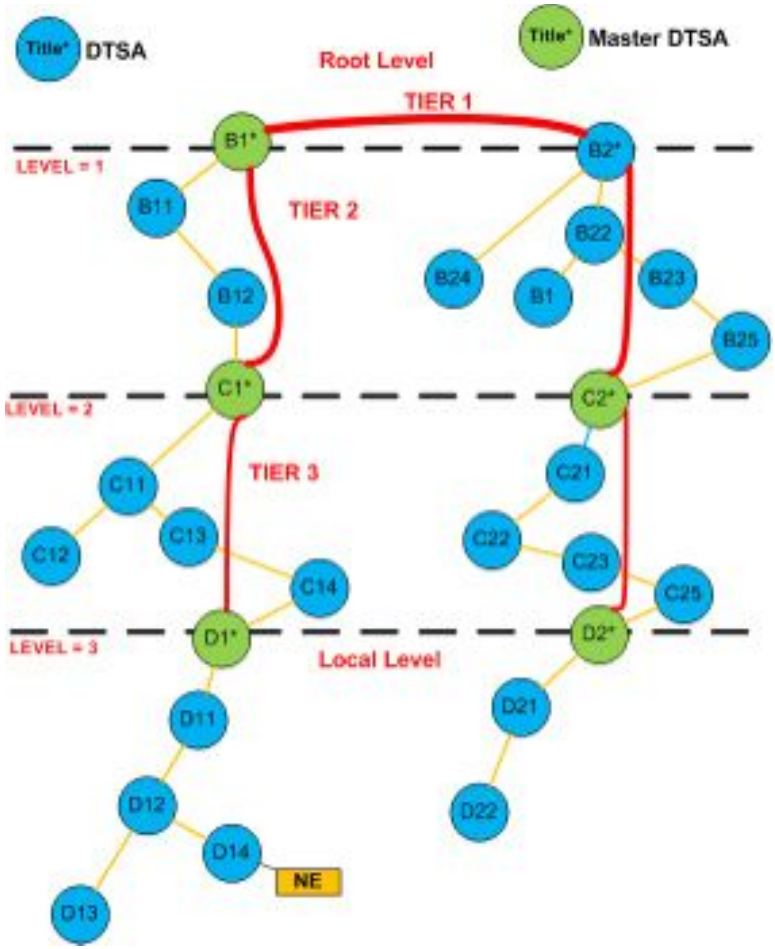
Domain Title Service

- Overview

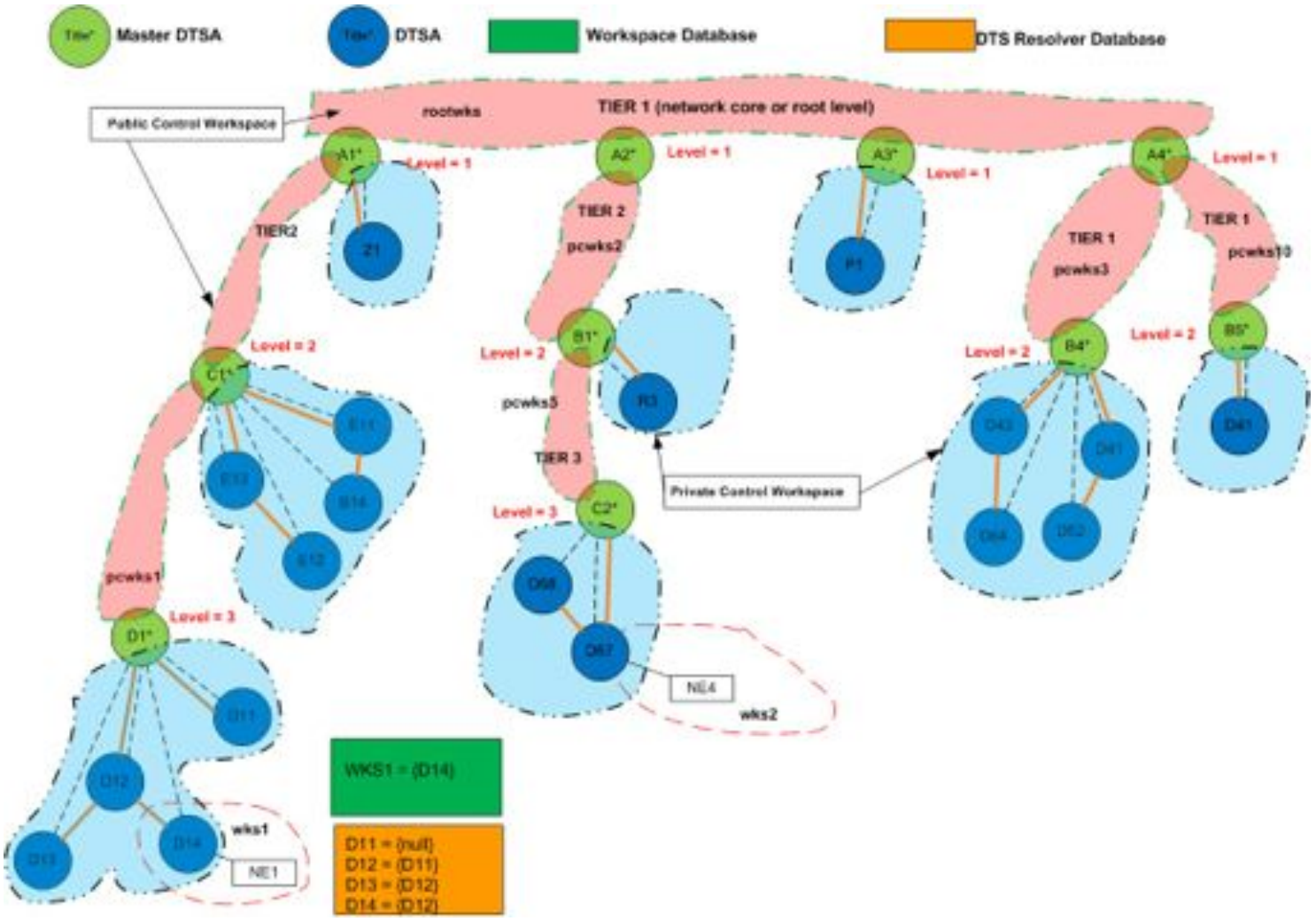


Domain Title Service

- DTS as a worldwide three level network

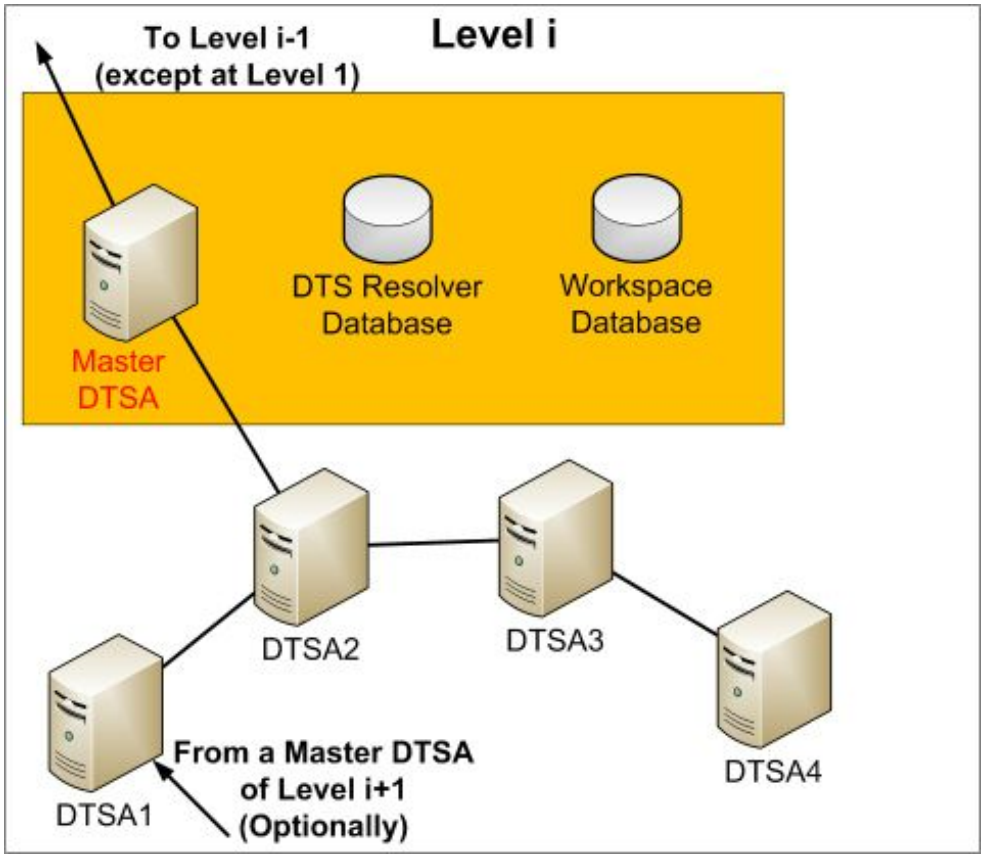


DTS Hierarchical Organization

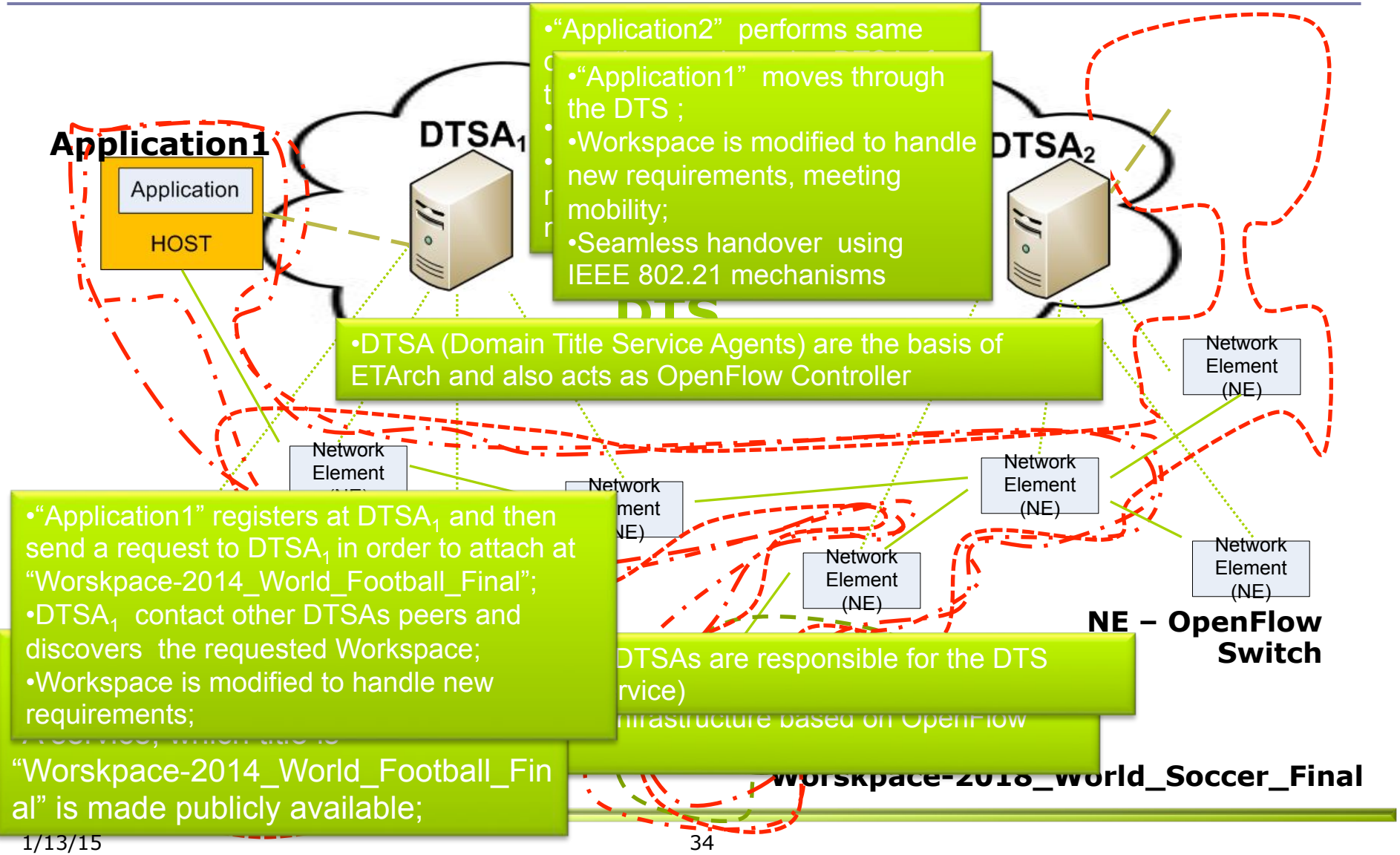


Domain Title Service

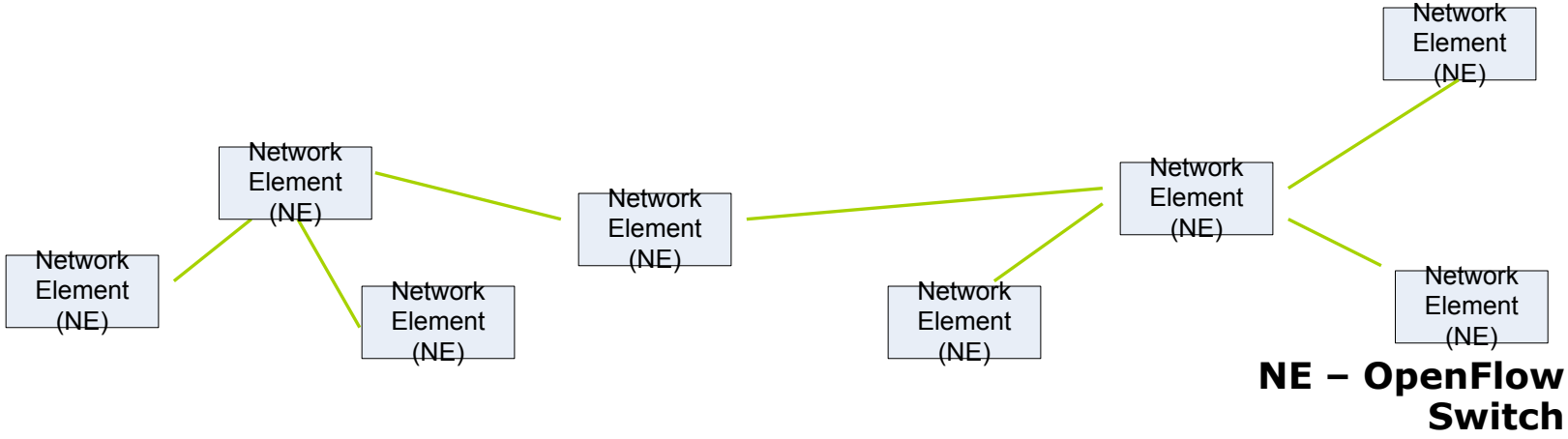
- Components of a generic level of the DTS



Entity Title Architecture Overview

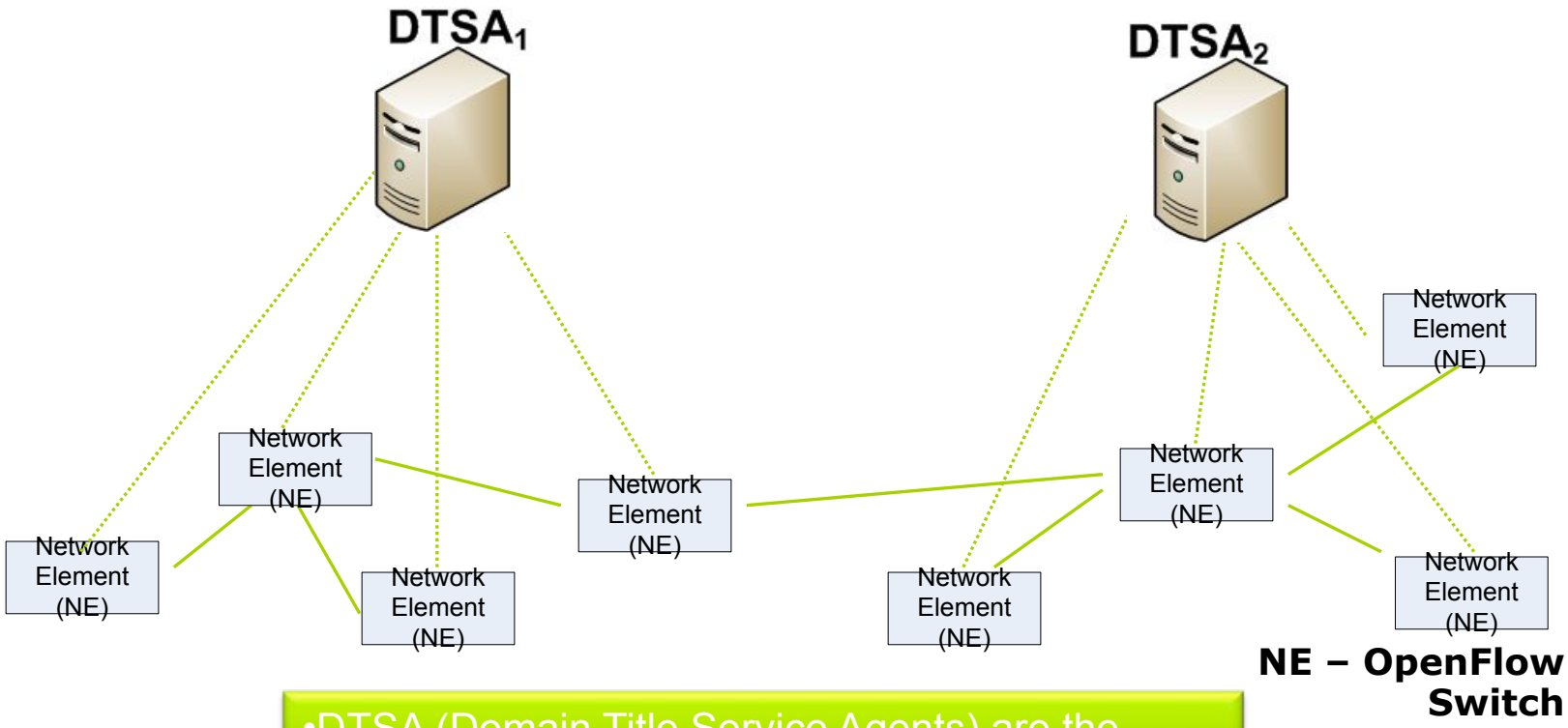


Entity Title Architecture Overview



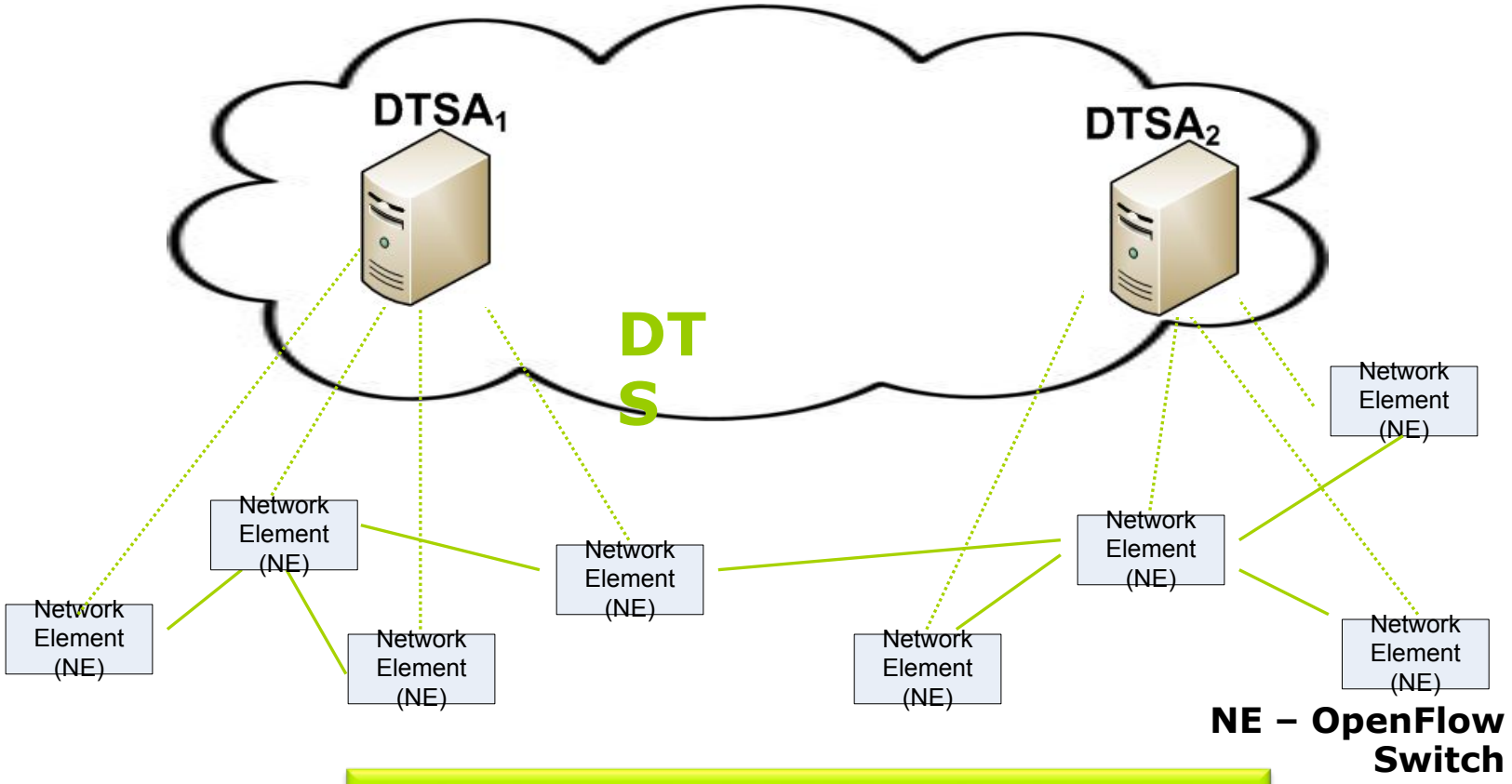
•Let's Consider an infrastructure based on OpenFlow switches

Entity Title Architecture Overview



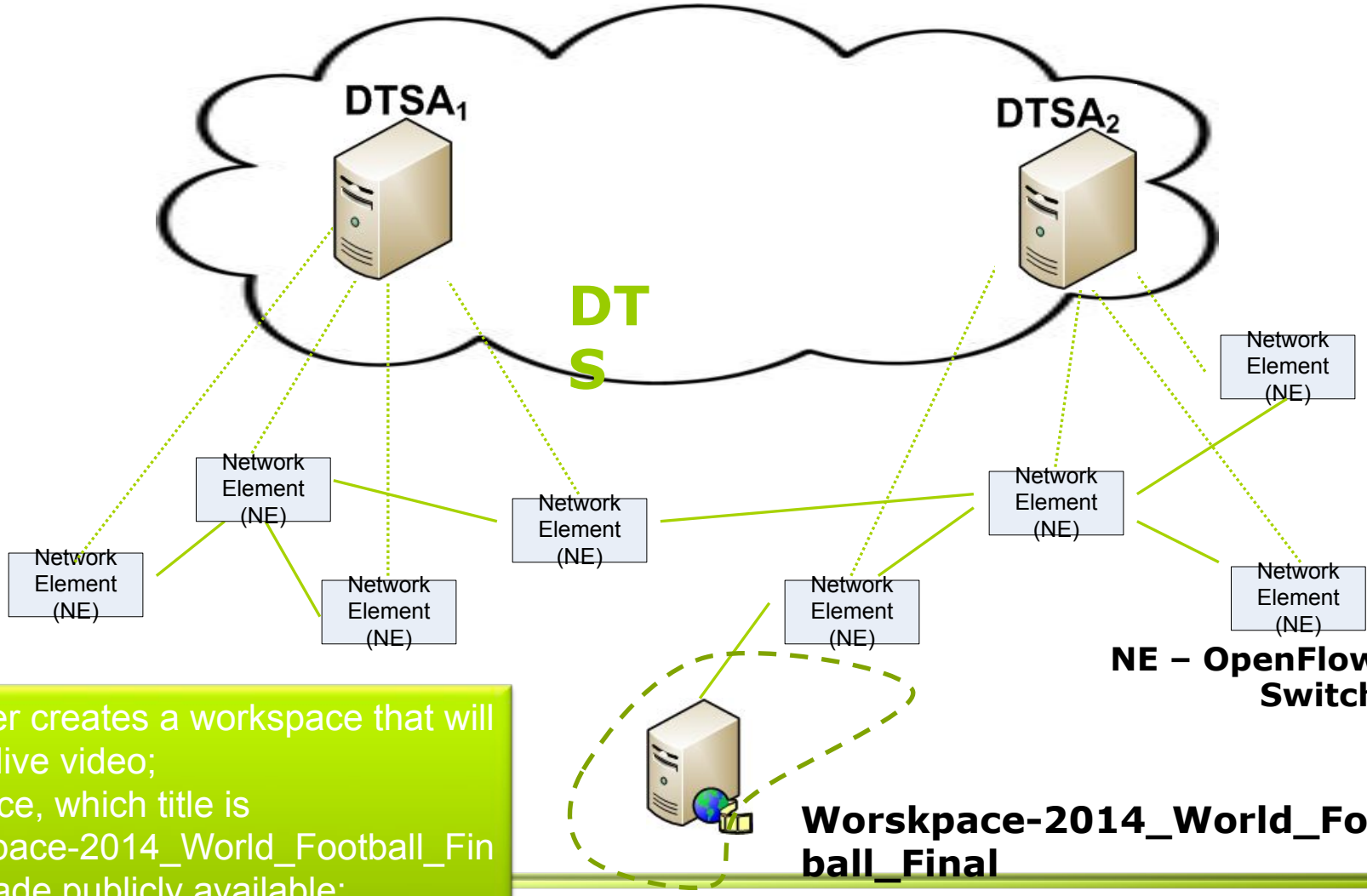
•DTSA (Domain Title Service Agents) are the basis of ETArch and also acts as OpenFlow Controller

Entity Title Architecture Overview



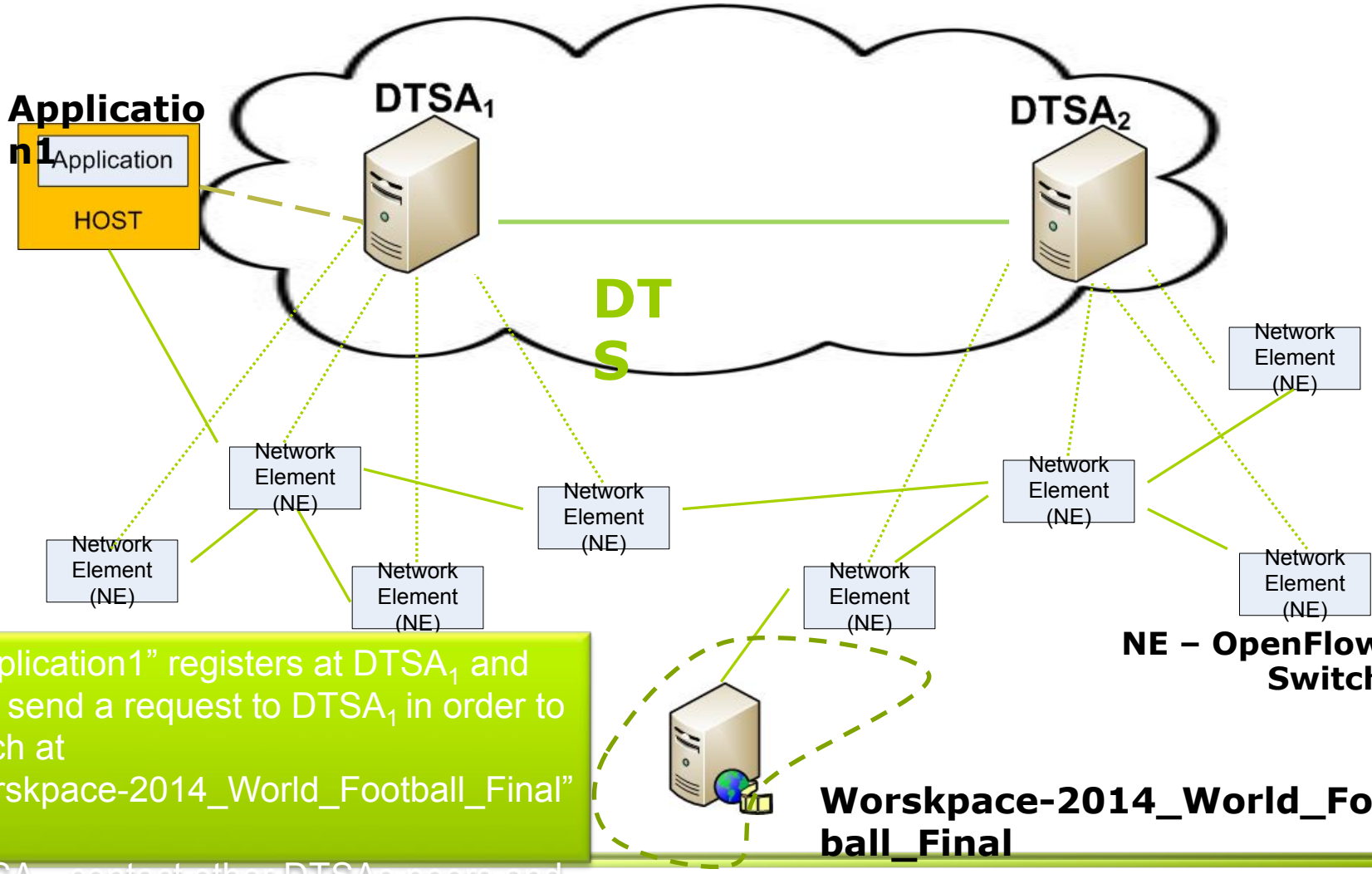
•Interconnected DTSAs are responsible for the DTS (Domain Title Service)

Entity Title Architecture Overview



- A server creates a workspace that will stream live video;
- A service, which title is "Worskpace-2014_World_Football_Final" is made publicly available;

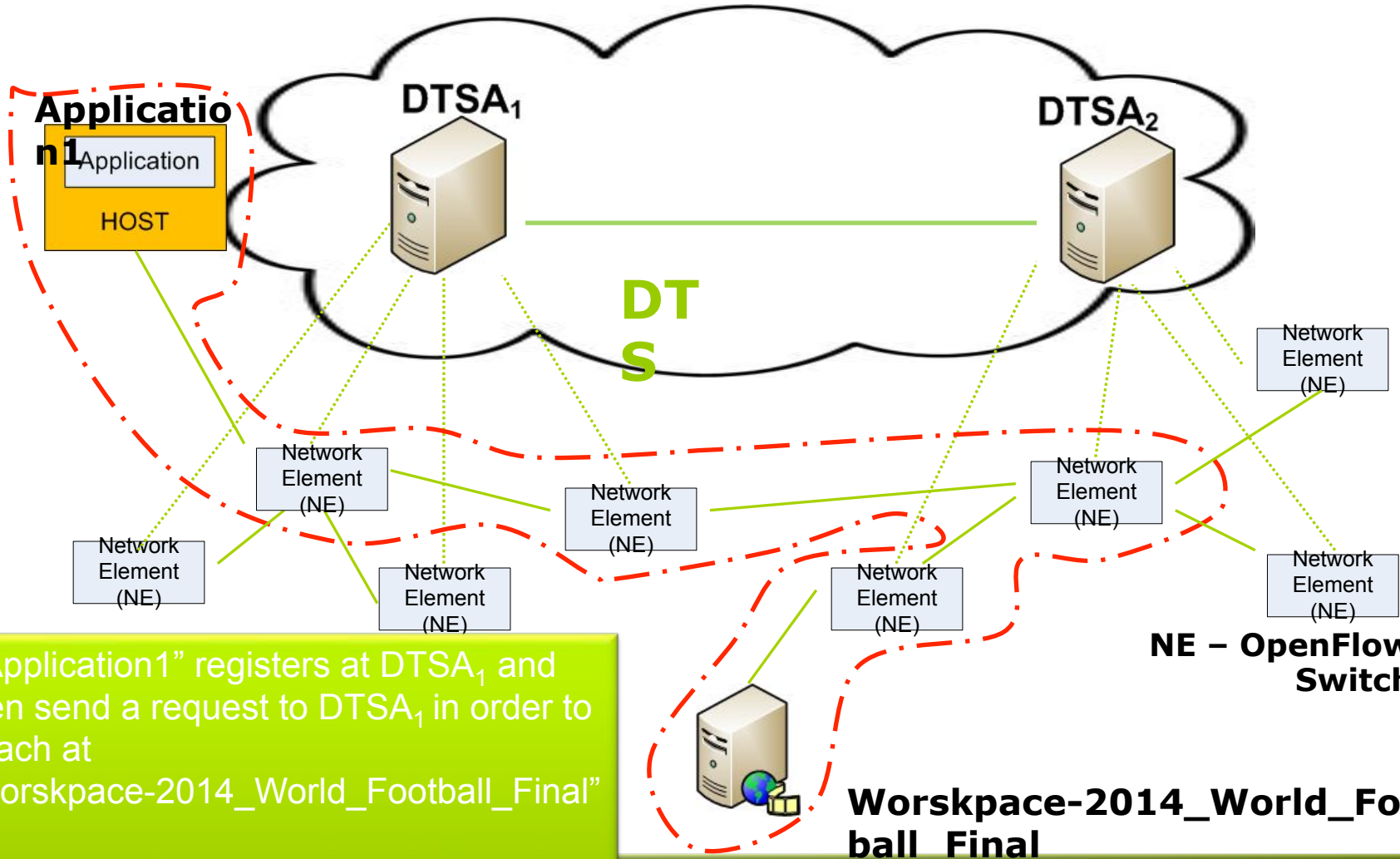
Entity Title Architecture Overview



•"Application1" registers at $DTSA_1$ and then send a request to $DTSA_1$ in order to attach at "Worskpace-2014_World_Football_Final" ;

•$DTSA_1$ contact other DTSAs peers and discovers the requested Workspace;

Entity Title Architecture Overview



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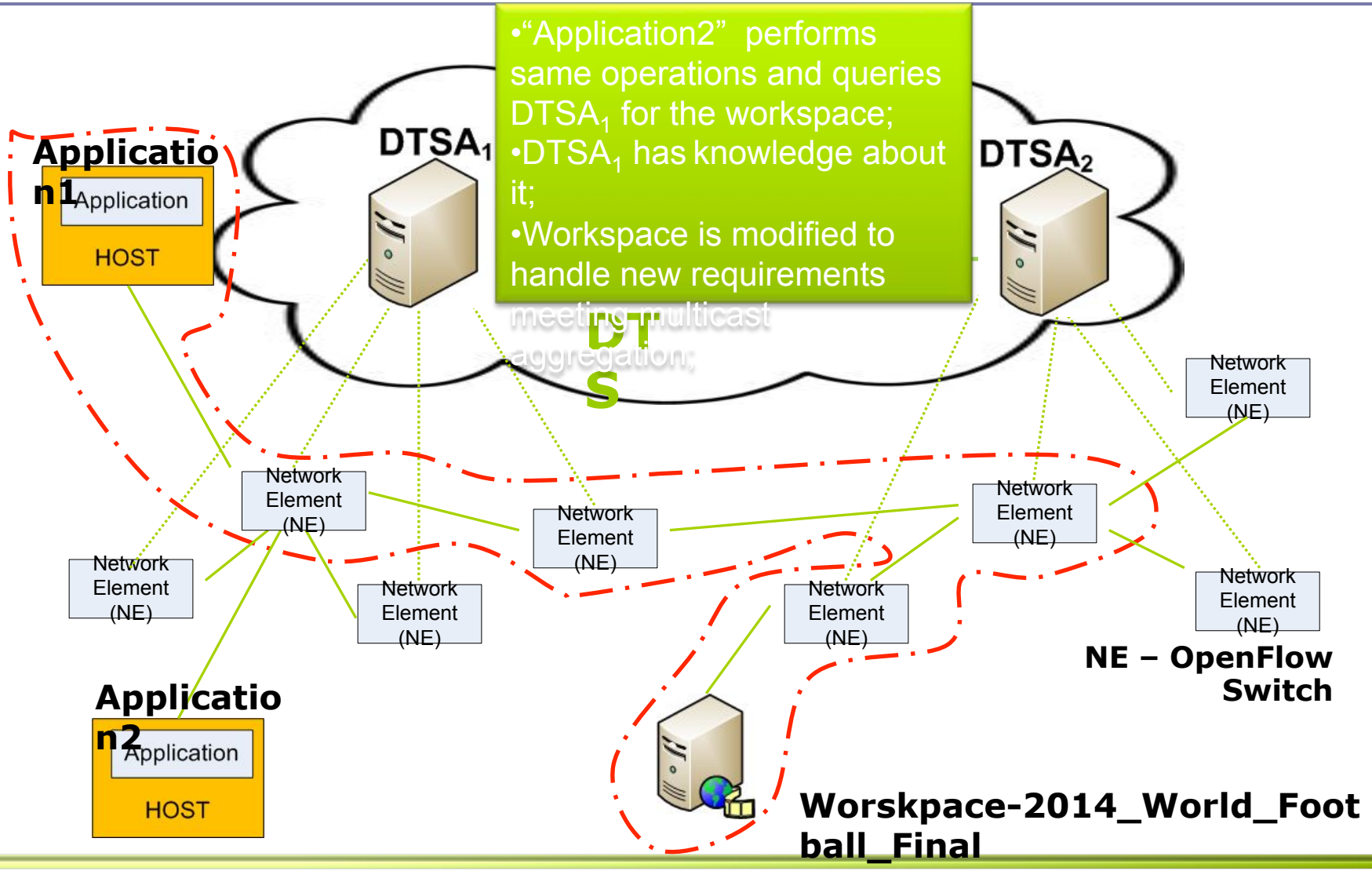
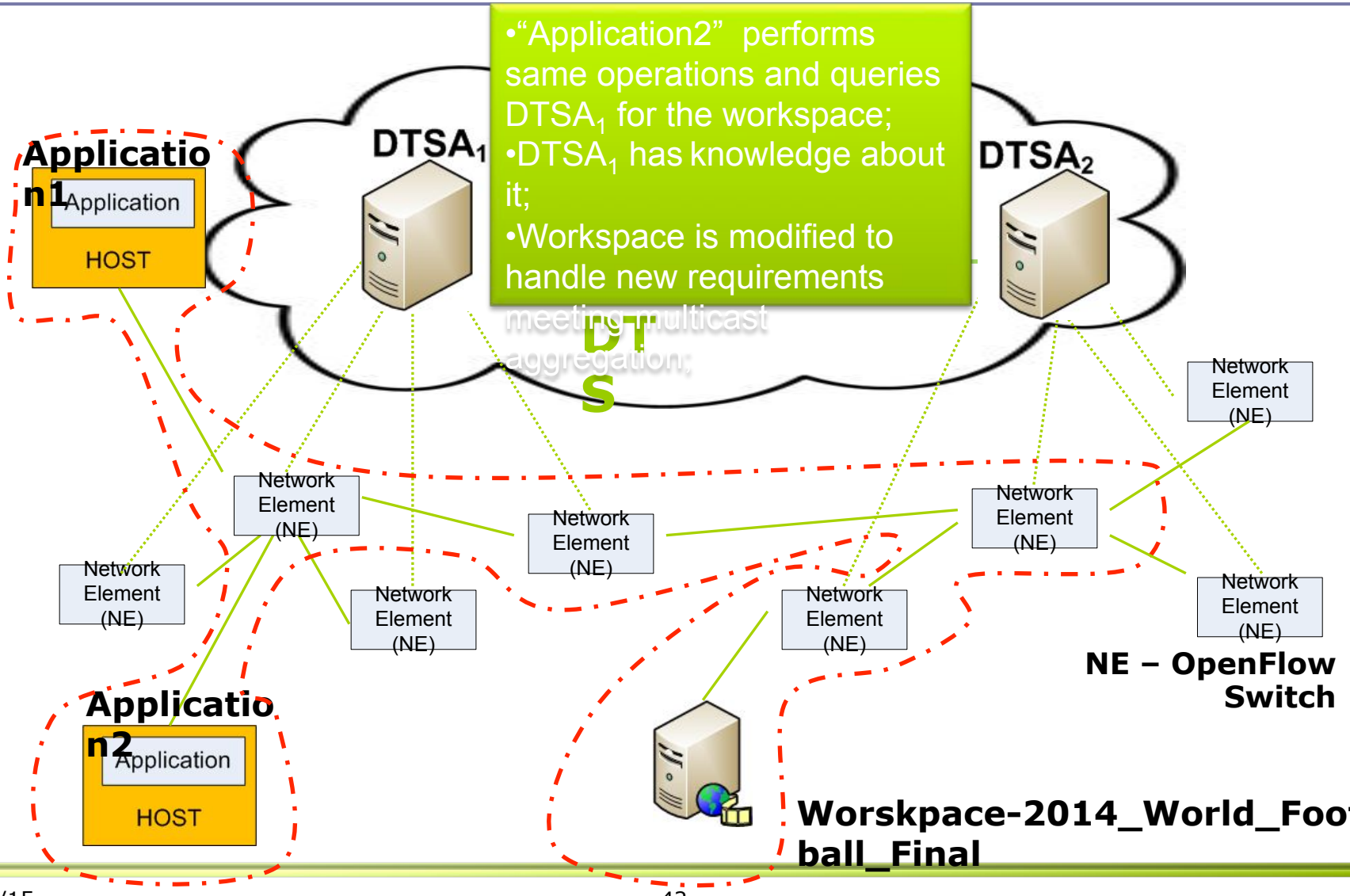
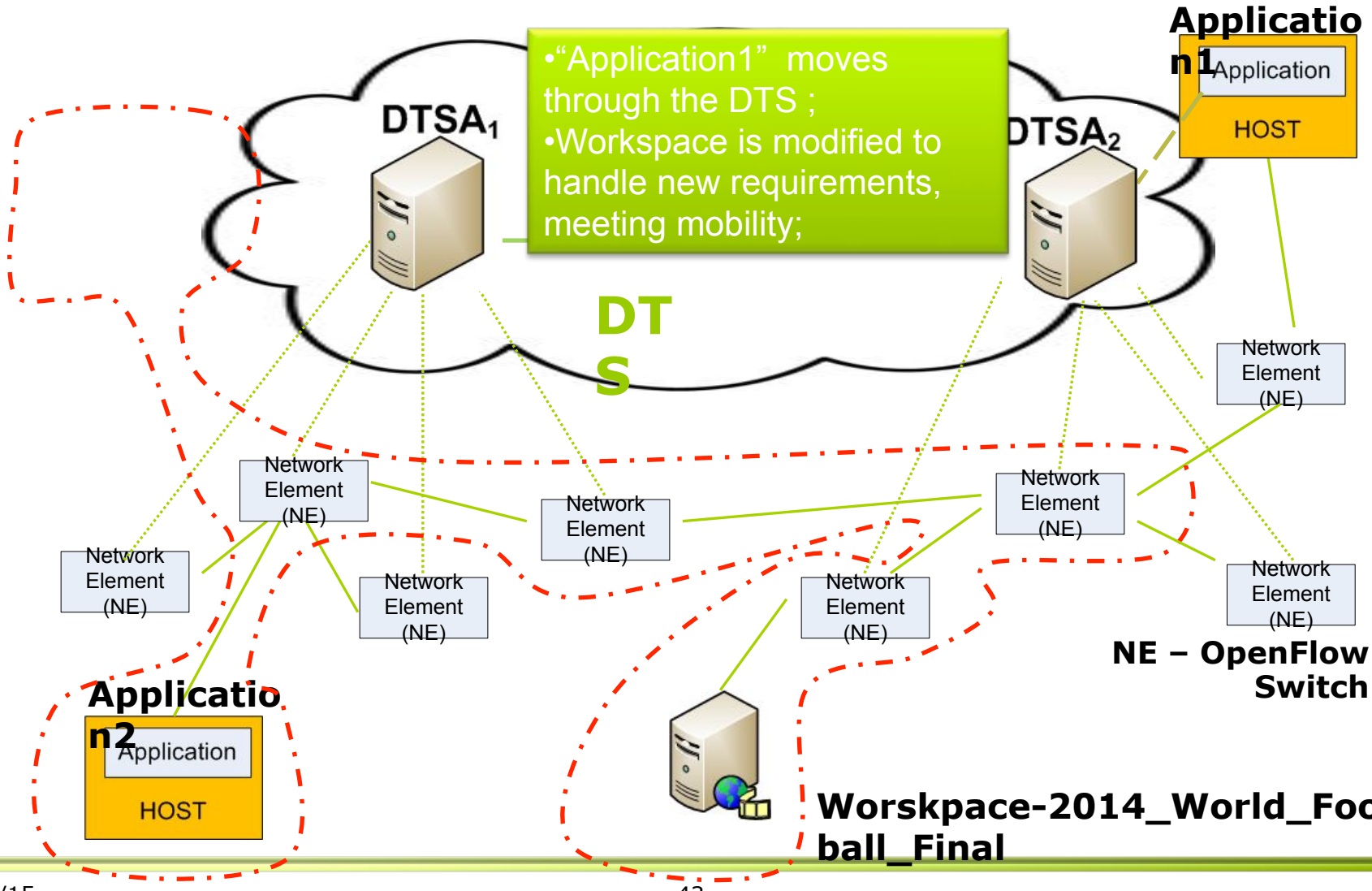
Entity Title Architecture Overview



Entity Title Architecture Overview



Entity Title Architecture Overview



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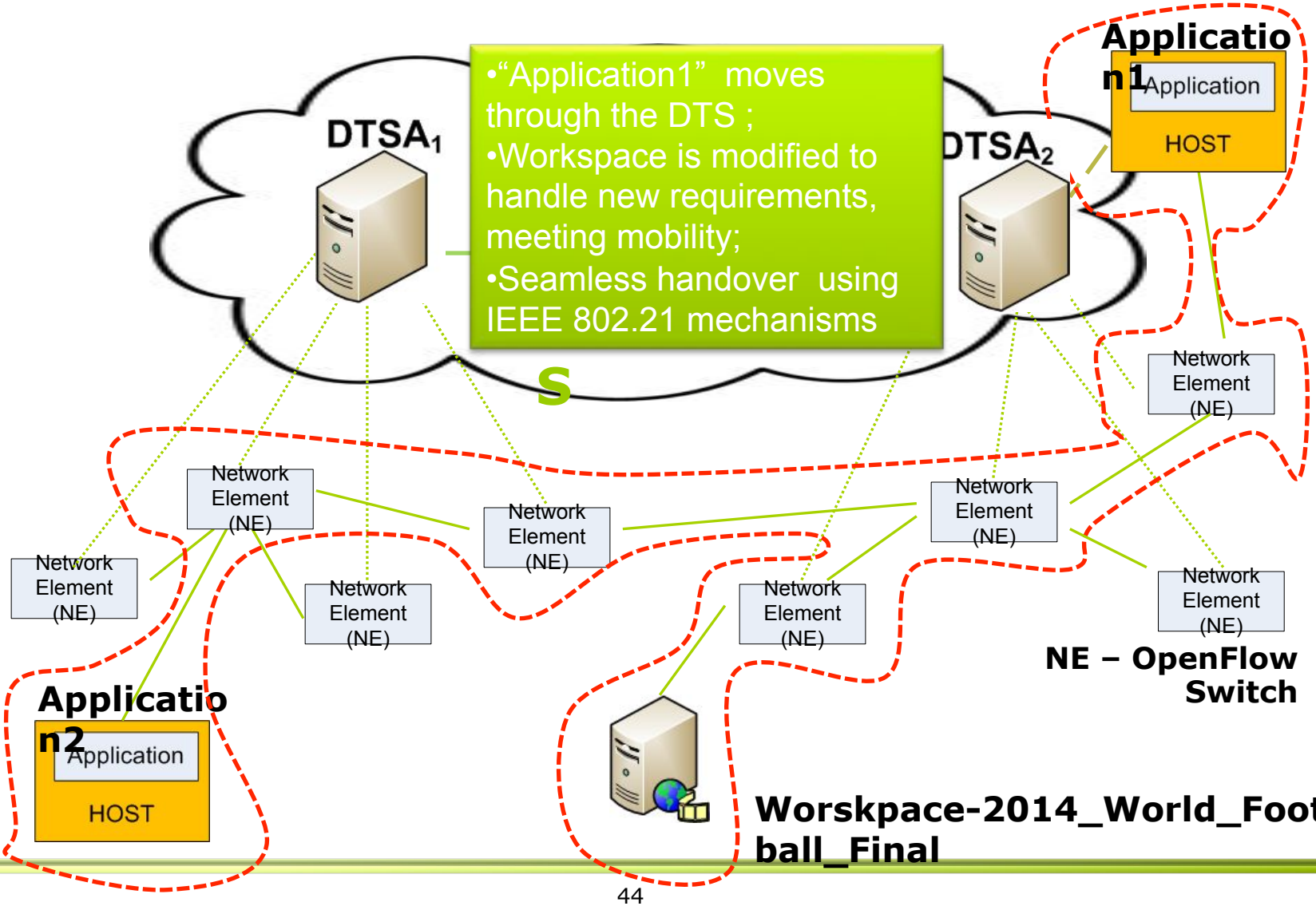
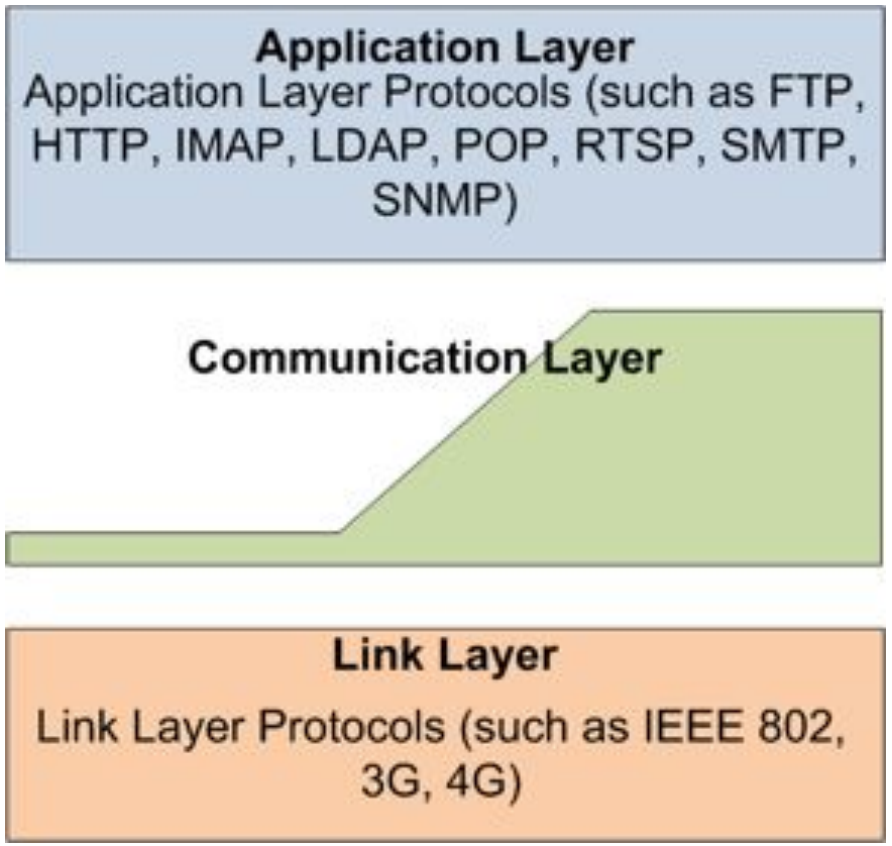


Layers

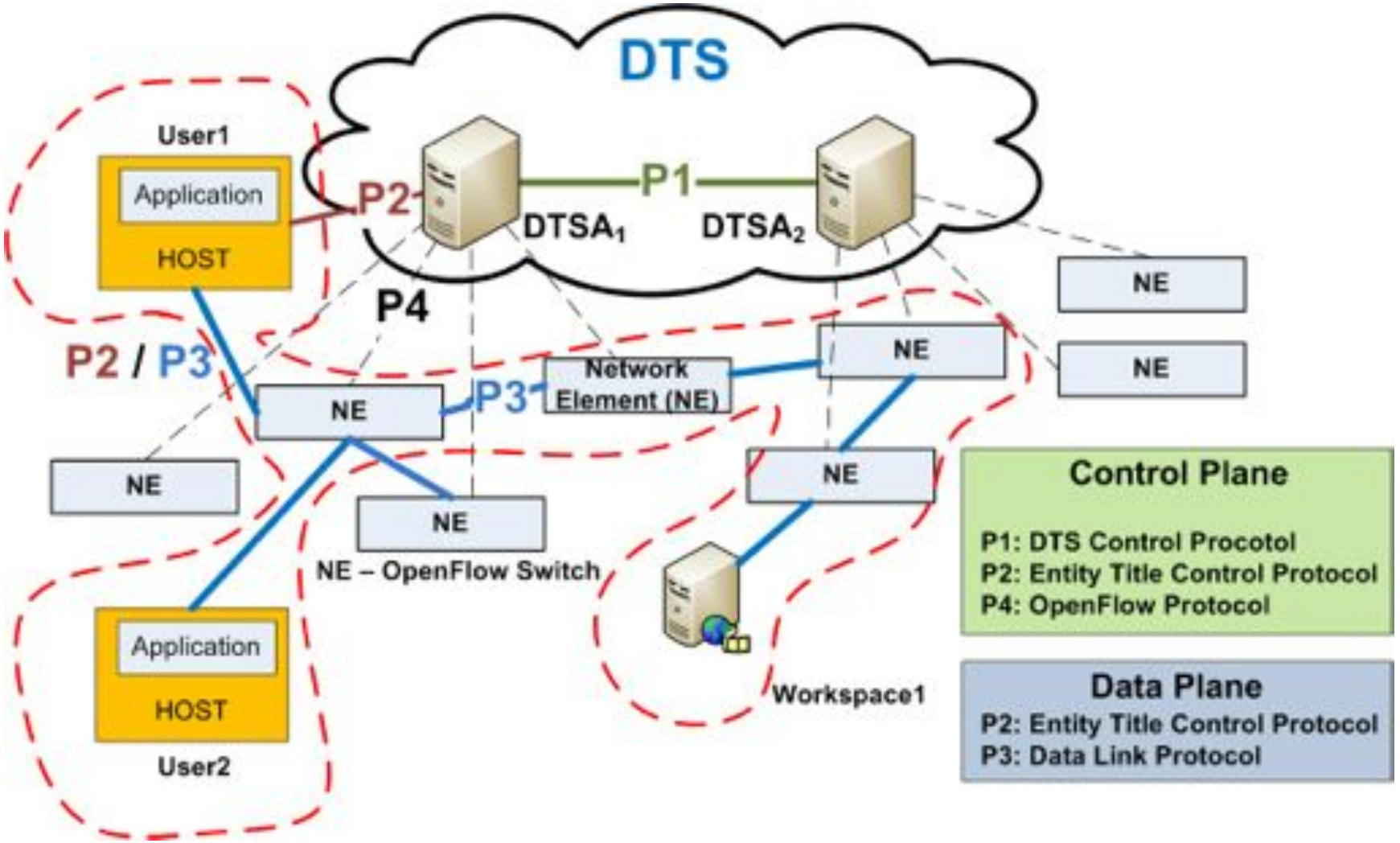
- Layer Architectural Pattern as the start point



Layers

- Application Layer
  - Assumes that current application protocols, widely deployed, are supported by the architecture.
  - To exploit new service abstractions, a new socket type was defined for the architecture and to be compatible, current applications must be updated.
- Communication Layer
  - Essence of the architecture and contains its specific protocols.
  - Its unusual representation is meant to show that it may provide different "thickness" of services to the adjacent layers.
    - Local network
      - Packet ordering can be required and no routing is necessary, thus, the thin portion of layer is used.
    - Scenario with Internetworking, with secrecy and QoS
      - The full layer is used instead.
- Link Layer
  - Considers the Data Link and Physical layers

Entity Title Architecture Protocols



Entity Title Control Protocol (ETCP)

PROTOCOL	PLANE	PRIMITIVE	SEMANTICS
ETCP	DATA	WORKSPACE-INVOKE	application call that enables the communication by using a given workspace
ETCP	DATA	WORKSPACE-REVOKE	application call that disables the communication by using a given workspace
ETCP	DATA	SEND	application call used to send data to a workspace
ETCP	DATA	RECEIVE	application call used to receive data from a workspace
ETCP	CONTROL	ENTITY-REGISTER	Registers an entity at the DTS. To be registered an entity must present its title, capabilities and communication requirements. To communicate the entity must first register itself
ETCP	CONTROL	WORKSPACE-CREATE	Creates a workspace locally at the DTSA. If the workspace has a public access after the successful creation, DTSA will advertise the workspace, by inserting an entry at the Workspace Database
ETCP	CONTROL	WORKSPACE-ATTACH	Attaches an entity to a workspace. To acomplish the attachment process, the DTSA will obtain all network elements and will configure them to extend that workspace
ETCP	CONTROL	WORKSPACE-MODIFY	TBD…
ETCP	CONTROL	ENTITY-UNREGISTER	Removes an entity from the DTS
ETCP	CONTROL	WORKSPACE-DETACH	Removes an entity from a existing workspace
ETCP	CONTROL	WORKSPACE-DELETE	Deletes a workspace and performs all clean up necessary at the NE of the current DTSA

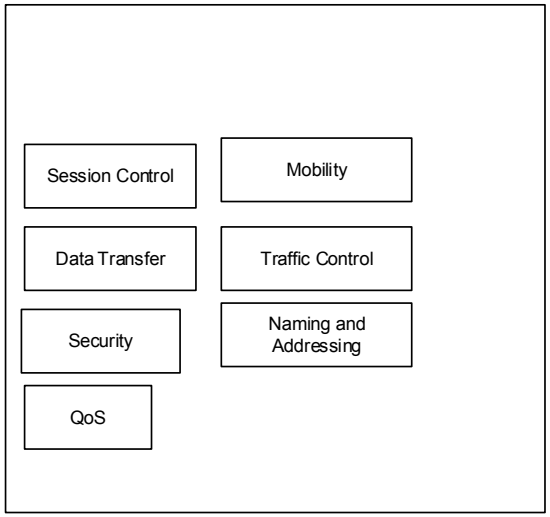
DTS Control Protocol (DTSCP)

PROTOCOL	PLANE	PRIMITIVE	SEMANTICS
DTSCP	CONTROL	WORKSPACE-LOOKUP	Sent by a DTSA to its resolvers, i.e. the MDTSA it is registered with. This primitive is used if an entity requests a **WORKSPACE-ATTACH** and the DTSA that it is registered to does not have information about this workspace. The workspace lookup will start at the level the DTSA is located and this request can be forwarded up to the root level.
DTSCP	CONTROL	DTSA-REGISTER	Responsible to register a DTSA at the DTS. To accomplish this, a entry at the DTSA Resolver Database will be inserted indicating who are the resolvers of that DTSA. The registration is performed by the MDTSA that belongs to the same Level of the DTSA that is being registered
DTSCP	CONTROL	WORKSPACE-ADVERTISE	Inserts, deletes, or updates the Workspace Database, by indicating that a DTSA is part of the DTSA set of a specific workspace. The Operation receives the level indicating the visibility of that workspace. The DTSA stored at the Workspace Database must be of the same level or can be a Master DTSA of the level right below
DTSCP	CONTROL	DTS-MESSAGE	Enables communication between different DTSAs inside the DTS. If the DTSA source knows the path to the DTSA destination, this path will be contained in the message header. Otherwise, the message will be forwarded to the resolvers, until one of them knows how to compute the path to the destination DTSA. If the Master DTSA of the Root Level cannot compute the path to destination, the message will fail.

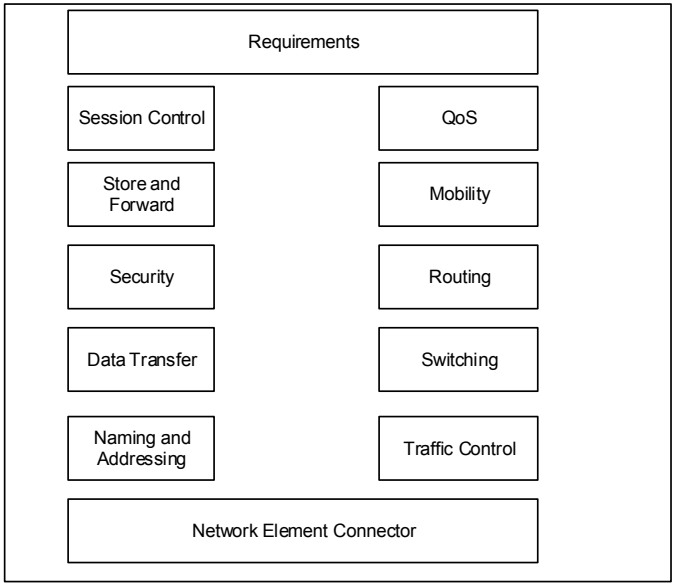
DTSA x SDN and NFV

- Common match with Software Defined Networking (SDN) and Network Function Virtualization (NFV)

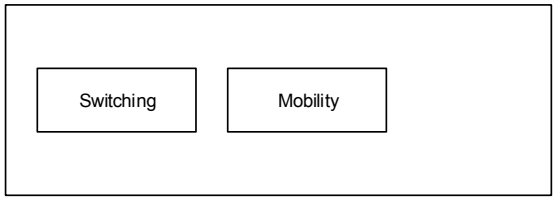
Endpoint



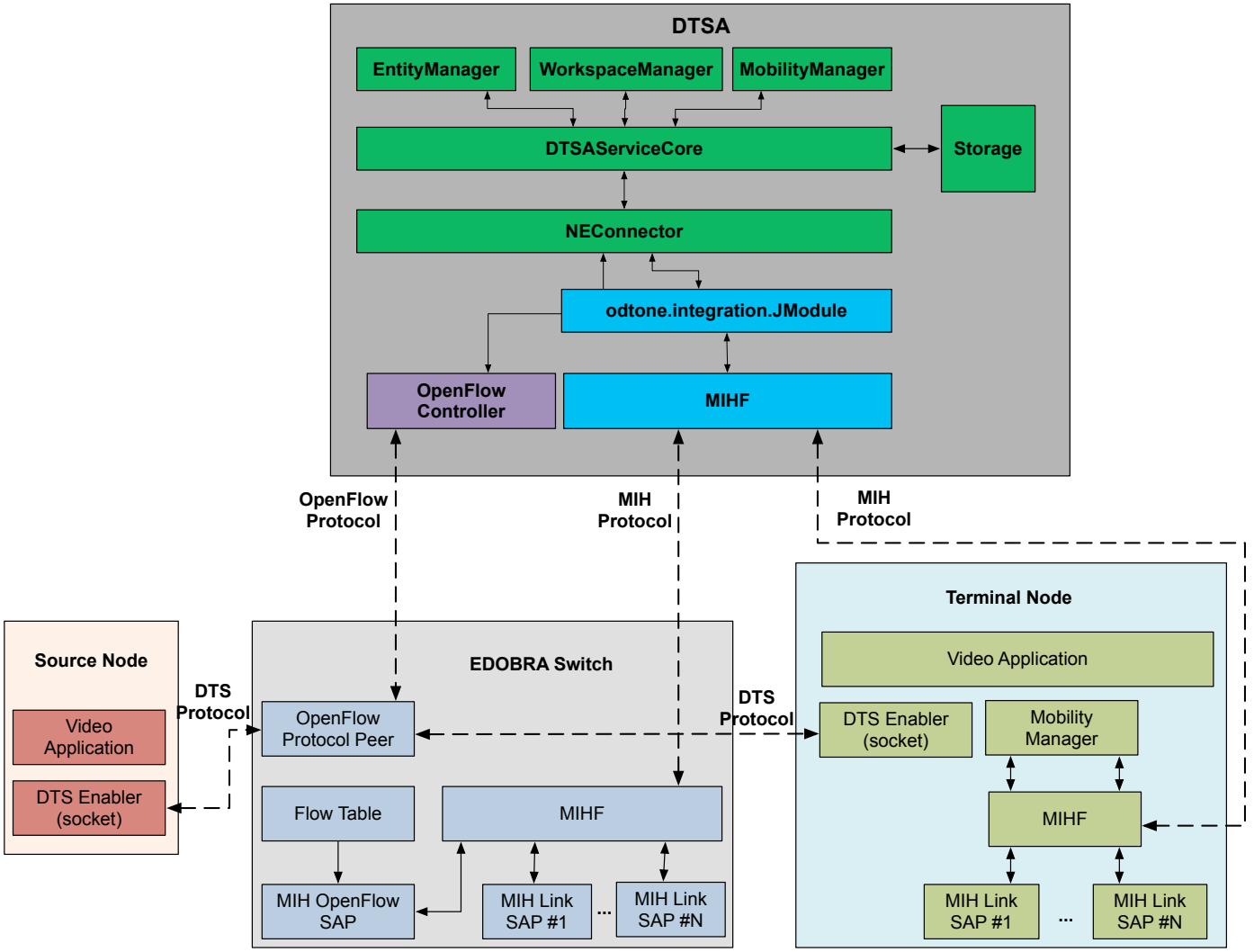
DTSA



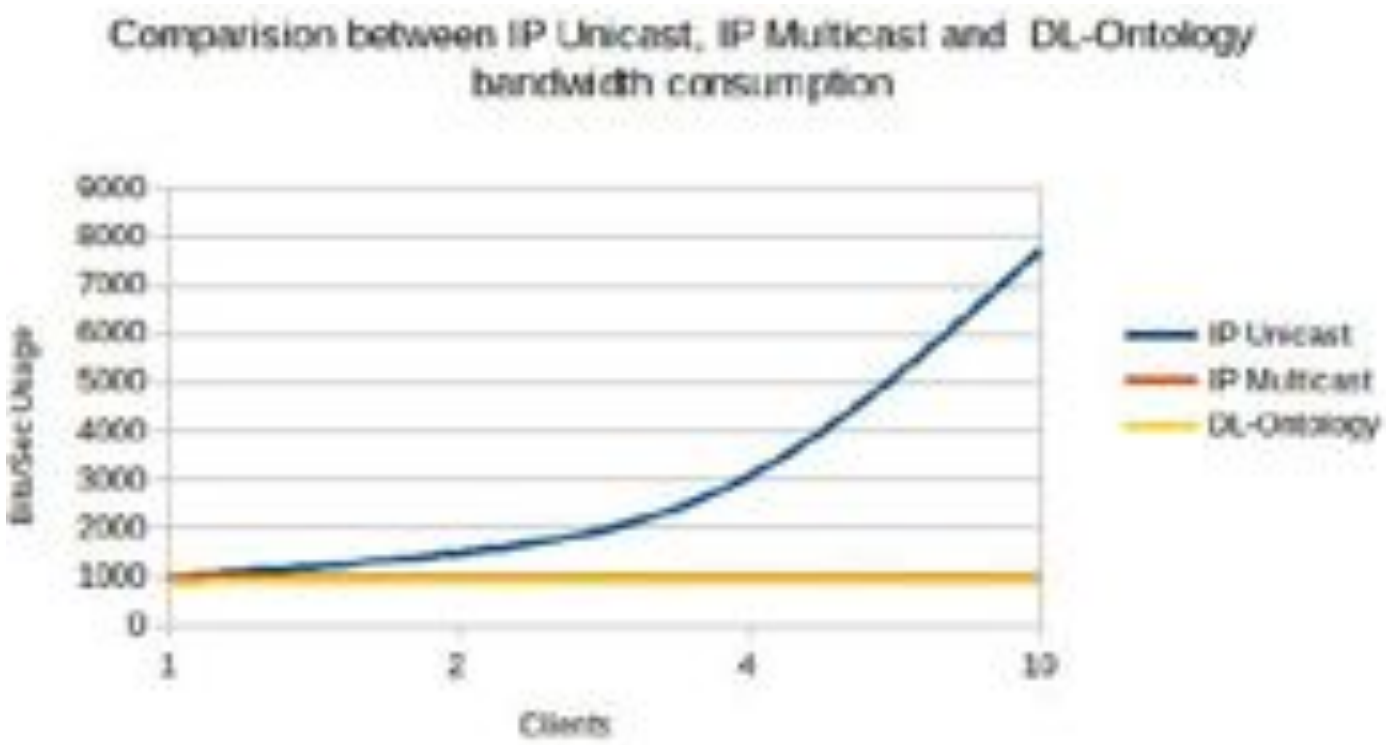
Network Element



Overview of ETArch

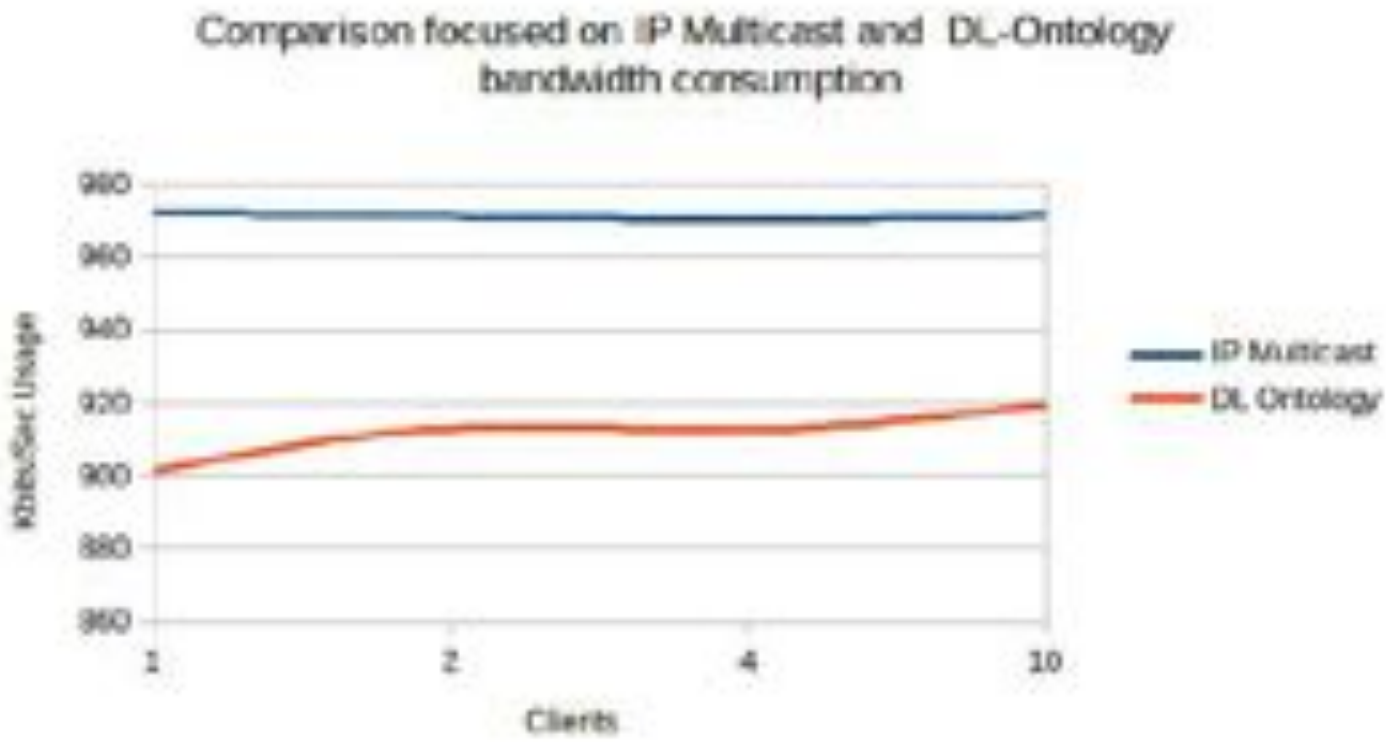


ETArch Multicast



AMARAL GONÇALVES, M. et al. **Multicast Traffic Aggregation through Entity Title Model**. In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. 2014

ETArch Multicast



AMARAL GONÇALVES, M. et al. **Multicast Traffic Aggregation through Entity Title Model**. In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. 2014

ETArch Concept
OpenFlow + IEEE 802.21

	No mobility awareness	Dummy mobility	IEEE 802.21 supported mobility
Total packets sent	3346,8 ± 2.1	3218 ± 10.3	3289,7 ± 24.9
Total packets received	950 ± 15.2	3078,4 ± 21.1	3218 ± 30.5
Total packet lost (%)	28,39 ± 0,44	4,34 ± 0,35	2.18 ± 0,33
Packet lost during HO	∞	70,9 ± 11.6	36,95 ± 12.2
Restore stream delay (ms)	∞	433,9 ± 68.2	197,2 ± 62.2
Redundancy (ms)	0 ± 0	0 ± 0	359,0 ± 62.7

TABLE I: Packet statistics

GUIMARÃES, C. et al. **Empowering Software Defined Wireless Networks Through Media Independent Handover Management**Globecom 2013 - Next Generation Networking Symposium (GC13 NGN). **Anais**...Atlanta, USA: 9 dez. 2013

ETArch Concept
OpenFlow + IEEE 802.21

		HO Preparation	HO Commit	HO Complete
Size (bytes)	IEEE 802.21 (UDP + Ack)	301	294	329
	OpenFlow (TCP)	0	736	688
Time (ms)	IEEE 802.21 (UDP + Ack)	11,73 ± 1,63	128,73 ± 12,41	122,90 ± 0,91
	OpenFlow (TCP)	0 ± 0	56,71 ± 0,85	56,17 ± 0,49

TABLE II: Total signaling overhead per handover

GUIMARÃES, C. et al. **Empowering Software Defined Wireless Networks Through Media Independent Handover Management**Globecom 2013 - Next Generation Networking Symposium (GC13 NGN). **Anais**...Atlanta, USA: 9 dez. 2013

ETArch Mobility

	ETArch with IEEE 802.21	ETArch only
Lost packets during HO	≈ 0	19.4 ± 1.0
Restore stream delay (ms)	≈ 0	407.9 ± 26.9
Redundancy at MN (ms)	40.3 ± 12.4	0
Redundancy at network (ms)	851.7 ± 32.1	0
Redundancy at network (packets)	39.6 ± 3.1	0

TABLE I: Content reception performance comparison

GUIMARAES, C. et al. **IEEE 802.21-enabled Entity Title Architecture for Handover Optimization**2014 IEEE Wireless and Communications and Networking Conference. **Anais**... In: 2014 IEEE WIRELESS AND COMMUNICATIONS AND NETWORKING CONFERENCE. Piscataway, NJ:: IEEE, 2014

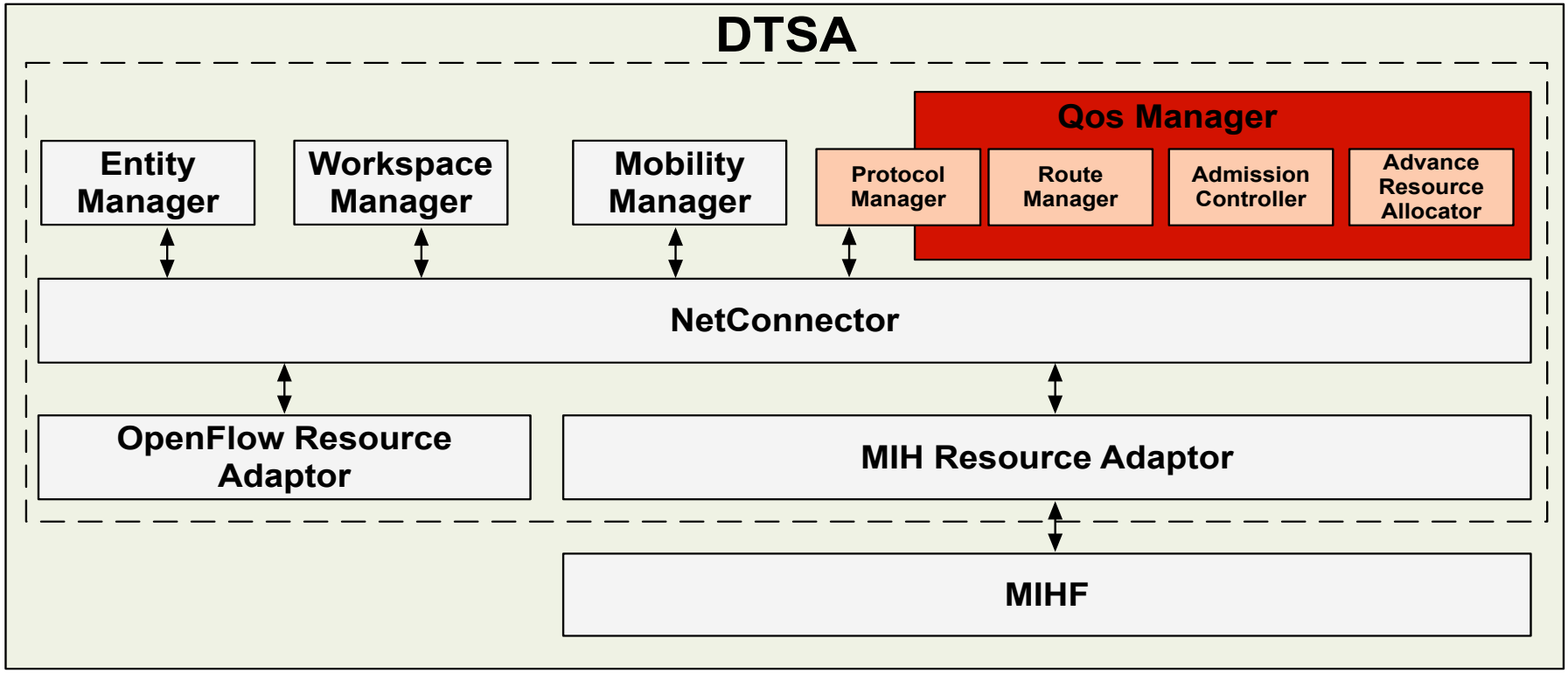
ETArch Mobility

		HO Preparation	HO Commit	HO Complete
Size (bytes)	IEEE 802.21	235	171	218
	OpenFlow	0	2568	0
	DTS	0	0	0
Time (ms)		108.3 ± 18.5	65.7 ± 17.5	32.0 ± 10.9

TABLE II: Total signaling overhead per handover

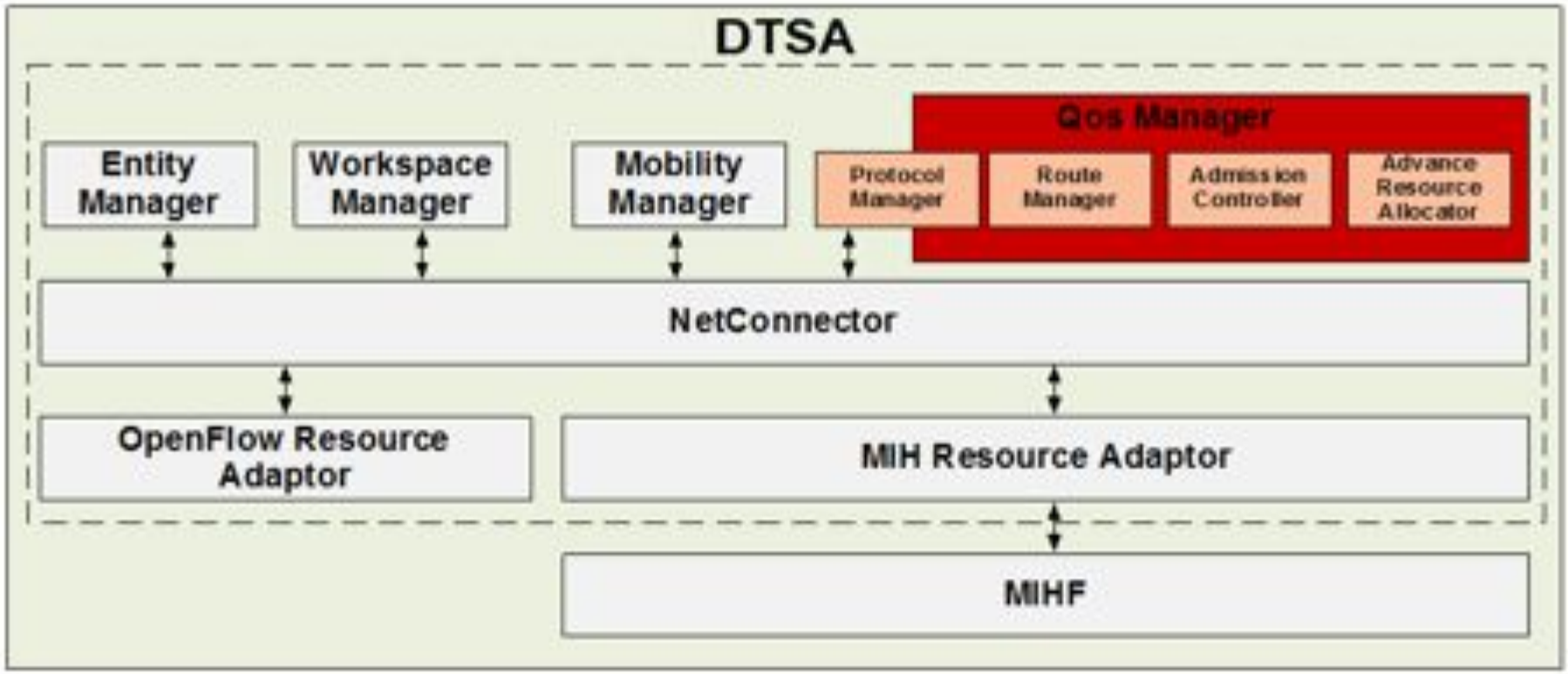
GUIMARAES, C. et al. **IEEE 802.21-enabled Entity Title Architecture for Handover Optimization**2014 IEEE Wireless and Communications and Networking Conference. **Anais**... In: 2014 IEEE WIRELESS AND COMMUNICATIONS AND NETWORKING CONFERENCE. Piscataway, NJ:: IEEE, 2014

SMART
Support of Mobile Sessions with High Transport Network Resource Demand

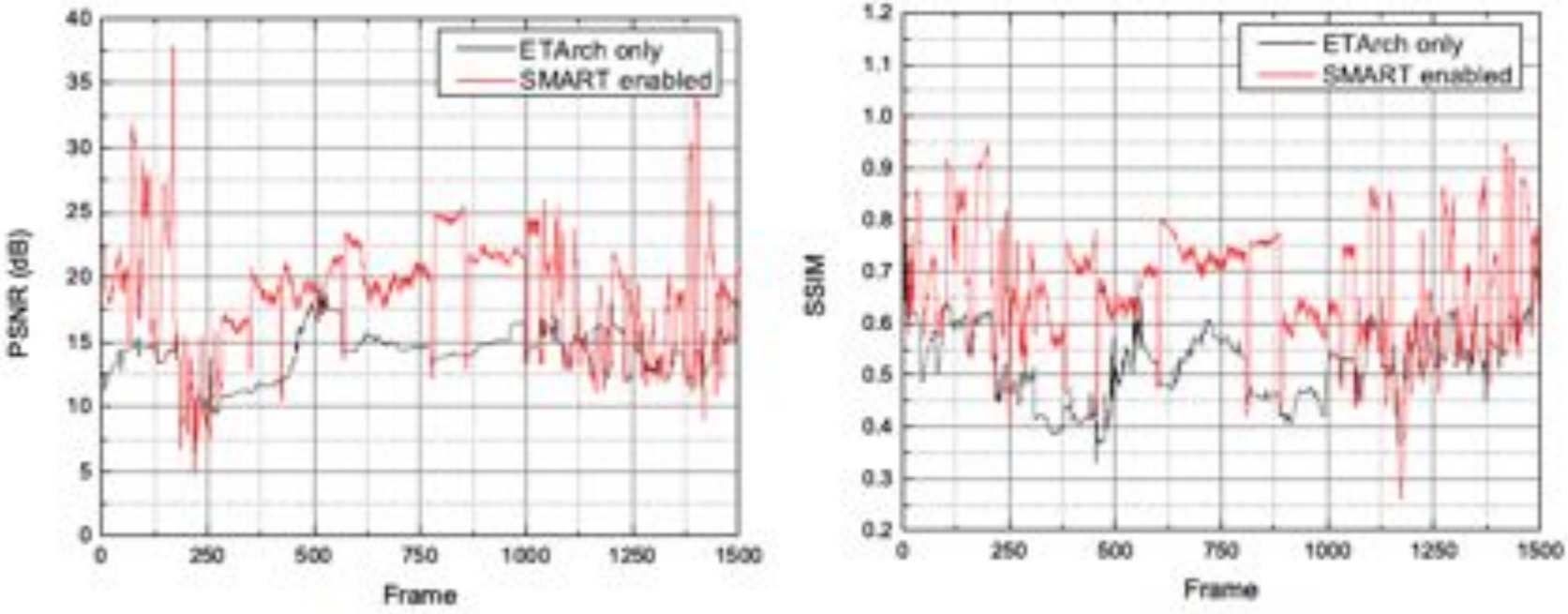


SMART
Support of Mobile Sessions with High Transport Network Resource Demand

- Enhancement of ETArch to support QoS and QoE



SMART
Support of Mobile Sessions with High Transport Network Resource Demand

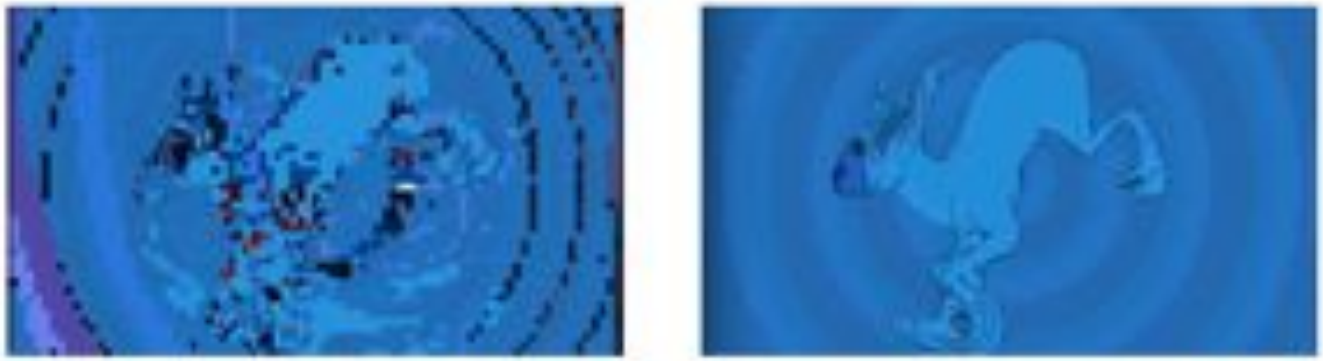


(a) PSNR metric (b) SSIM metric

Figure 4: QoE metrics for multimedia video streaming

CASTILLO-LEMMA, J. et al. **Evolving Future Internet Clean-Slate Entity Title Architecture with Quality-Oriented Control Plane Extensions.**The Tenth Advanced International Conference on Telecommunications (AICT). **Anais**... In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. Paris: IARIA, jul. 2014

SMART
Support of Mobile Sessions with High Transport Network Resource Demand



(a) Frame without SMART (b) Same Frame using SMART

Figure 5: Video snapshot comparison

CASTILLO-LEMMA, J. et al. **Evolving Future Internet Clean-Slate Entity Title Architecture with Quality-Oriented Control Plane Extensions.**The Tenth Advanced International Conference on Telecommunications (AICT). **Anais**... In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. Paris: IARIA, jul. 2014

SMART
Support of Mobile Sessions with High Transport Network Resource Demand

TABLE I: FORWARDING TABLE SIZES AT CORE ROUTERS

	ETArch with SMART	ETArch only
University of Texas (2011 report)	952	20.000
University of Texas (2013 report)	1.330	40.000
University of Texas (congested scenario)	1.330	80.000

CASTILLO-LEMMA, J. et al. **Evolving Future Internet Clean-Slate Entity Title Architecture with Quality-Oriented Control Plane Extensions.**The Tenth Advanced International Conference on Telecommunications (AICT). **Anais**... In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. Paris: IARIA, jul. 2014

CREDENCE - Carrier-grade softwaRE DEfined Networking Control Environment

- Motivation
  - SDN community is still in pursuit of a carrier grade SDN control layer that is suitable for demands of such environments
- Related Work
  - ONOS, OpenDayLight
- Objective
  - SDN controller architecture that is integrated with a carrier grade service level execution environment, based on the JAIN SLEE specification

CREDENCE Approach

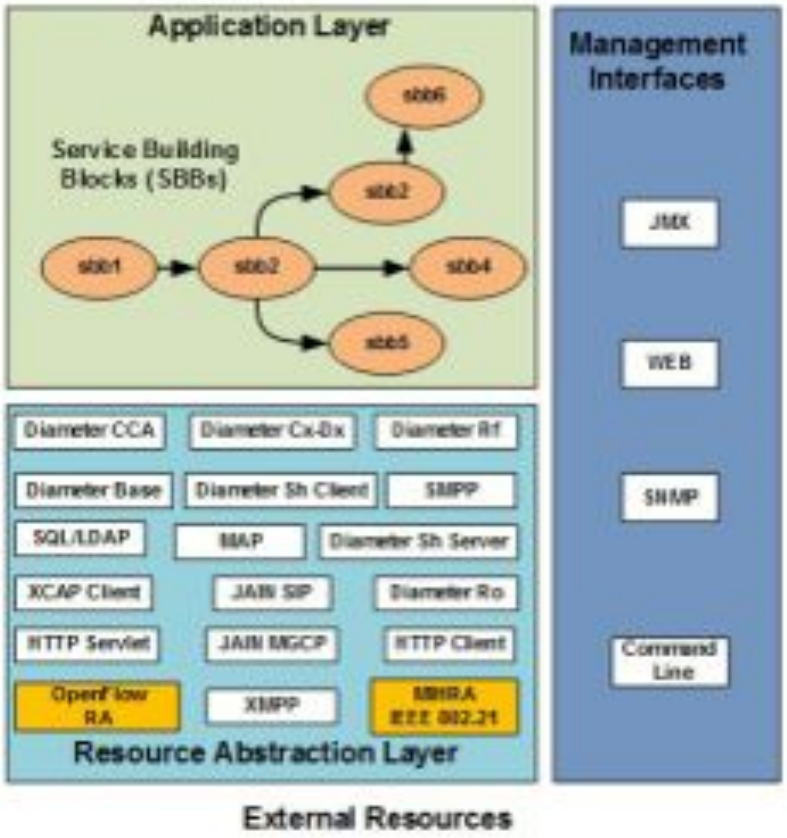


Figure 1: JAIN SLEE Architecture Main Components.

FERREIRA, C. C. et al. **Towards a Carrier Grade SDN Controller: Integrating OpenFlow with Telecom Services**The Tenth Advanced International Conference on Telecommunications (AICT). **Anais**... In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. Paris: IARIA, jul. 2014

CREDENCE
DTSA Application

- DTSA (Domain Title Service Agent) build on top of the presented solution

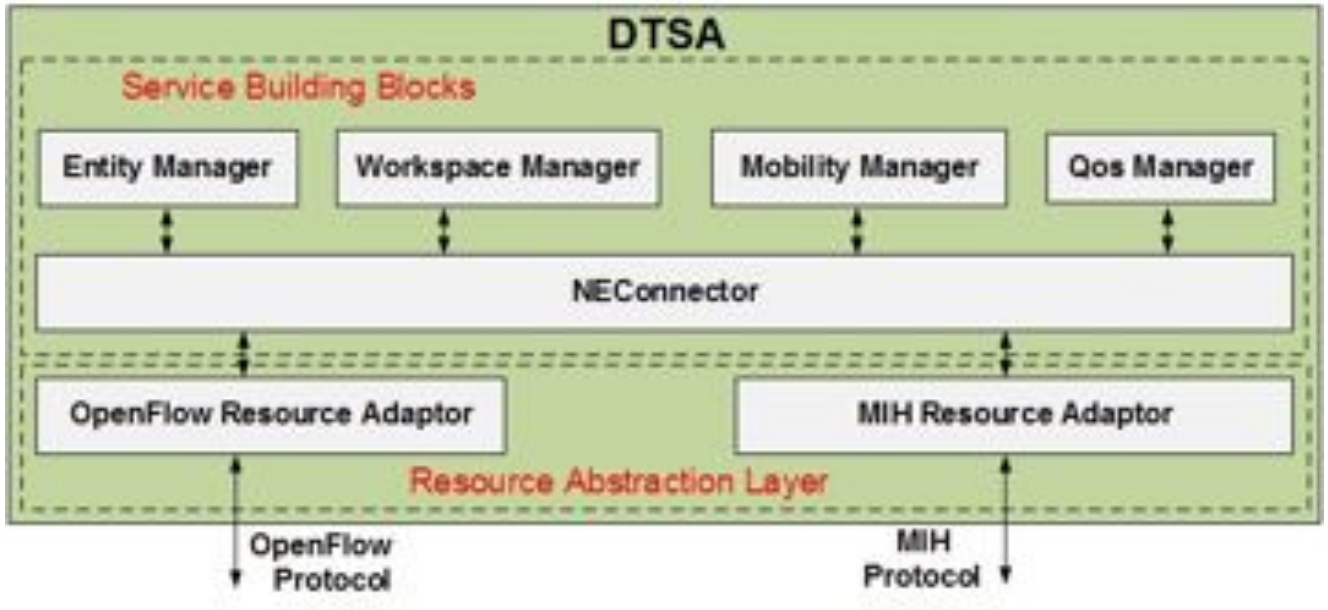


Figure 4: DTSA Components based on JAIN SLEE Component Model.

FERREIRA, C. C. et al. **Towards a Carrier Grade SDN Controller: Integrating OpenFlow with Telecom Services**The Tenth Advanced International Conference on Telecommunications (AICT). **Anais**... In: AICT 2014, THE TENTH ADVANCED INTERNATIONAL CONFERENCE ON TELECOMMUNICATIONS. Paris: IARIA, jul. 2014

ETArch PILOT

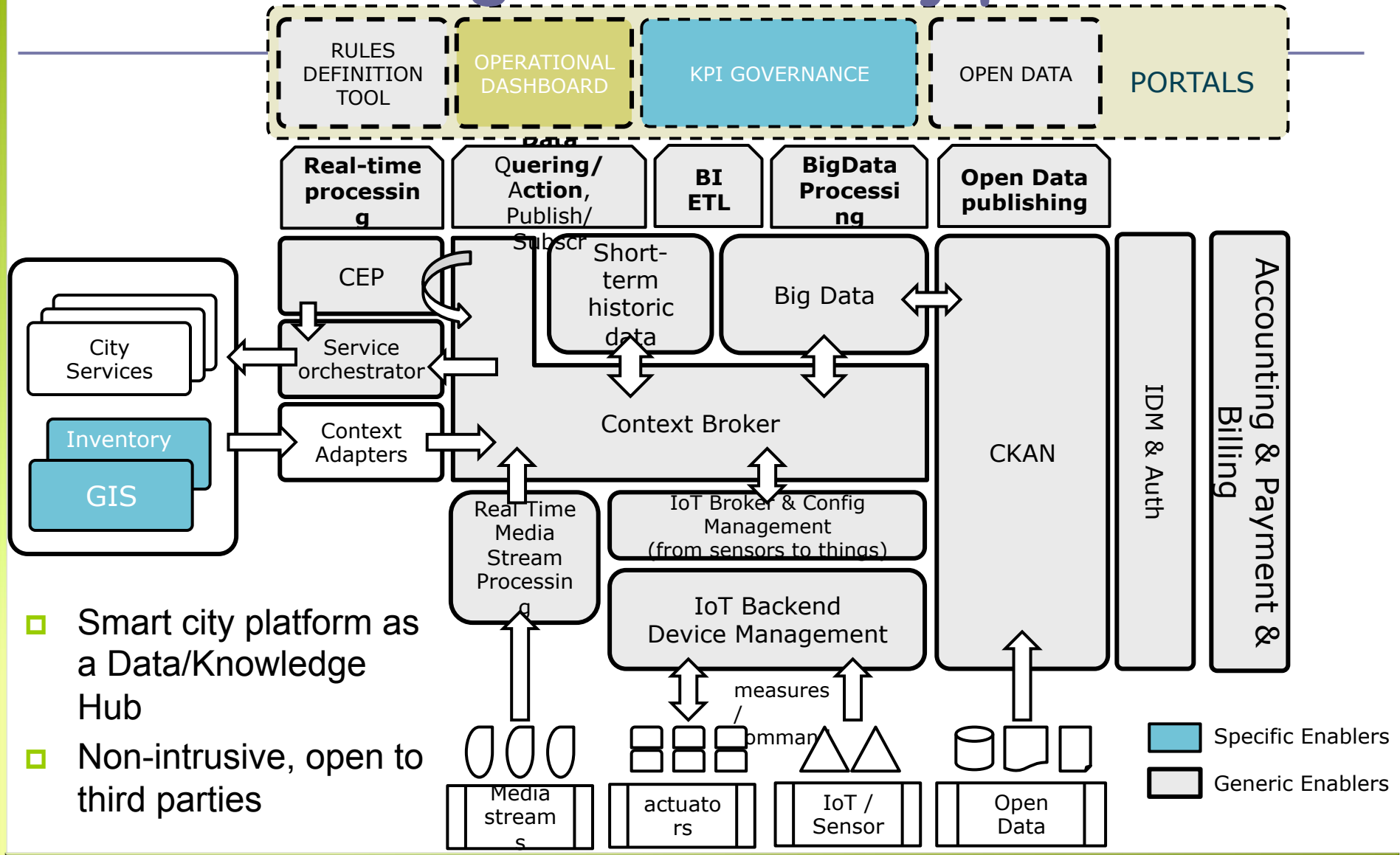
- Motivation
  - Bring research results closer to industry and operators
  - Platform to deploy new and innovative services
- Objective
  - Deploy ETArch at ALGAR's Telecom network
  - Use case on a real operator
  - Showcase SDN concepts

ETArch PILOT

FI-WARE FIILAB - Future Internet Innovation Laboratories

- Objectives
  - Create the conditions, at each region where the FIILAB is deployed, to support the development of innovative services and applications by local entrepreneurs
  - Explore FI-WARE Generic Enablers (GE), and Specific Enablers (SE) in order to reduce the time to market of these new services and applications
  - Deploy FI-Lab Nodes in Brazil, creating the conditions for entrepreneurs to reach the market
  - Design and deploy a GE in order to integrate the Entity Title Architecture (ETArch) to FI-WARE architecture
  - Collaborate with Future Internet initiatives fostering the use of technology that may help to provide a better living
- Nodes
  - UFU and USP Polytechnic School
  - Many others at Europe (www.fi-ware.org)

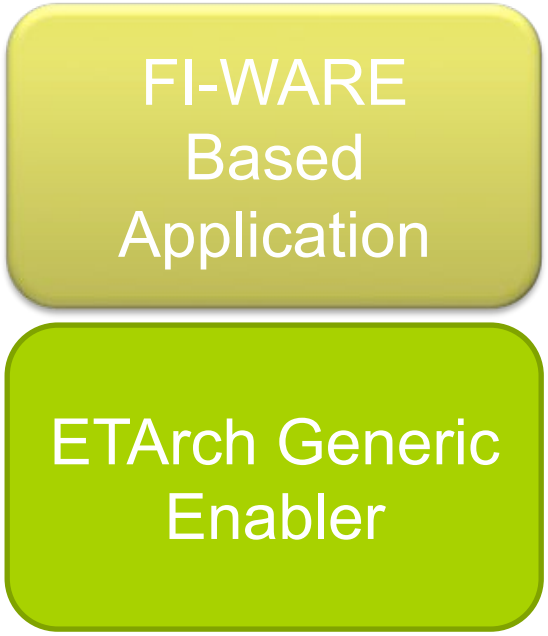
FI-WARE: Target Smart City platform



- Smart city platform as a Data/Knowledge Hub
- Non-intrusive, open to third parties

FI-WARE FIILAB - Future Internet Innovation Laboratories

- Integration between ETArch and FI-WARE software architecture



Potential Collaboration with US #1

- Rodrigo Fonseca
  - PANE on top of ETArch
- Christos Papadopoulos
  - NDN on top of ETArch
  - Joint work regarding ICN, by deploying NDN at ALGAR Telecom
- Ram Krishnan
  - Cooperation regarding security
- Andy Bavier
  - Planetlab node at Uberlândia
  - Joint experiments of ETArch using Planetlab
- Inder Monga
  - Joint experiments of ETArch using EEX
- Allen MacKenzie
  - Joint work regarding optimization of Wired and Wireless infrastructures
- Jason Liu (and Cesar Marcondes)
  - Traffic Modeling using real use case provided by ALGAR Telecom

Potential Collaboration with US #2

- In a broad sense
  - Future Internet requires worldwide collaboration
  - We are open to build strong and fruitful partnerships
  - Deploy different applications on top of ETArch
  - Deploy and run ETArch experiments using different infrastructures
  - Opportunity to work together with ALGAR Telecom in real world scenarios

Concluding Remarks

- ETArch
  - Meet users and applications new requirements
  - Multicast, Mobility, QoS and QoE
  - Express, control and manage requirements from top to bottom layers
- On going work…
- We are open to collaborate and to build a partnership

Thank you!

flavio@ufu.br

Prof. Flávio de Oliveira Silva, Ph.D.

FACOM - Faculty of Computing

UFU – Federal University of Uberlândia

ETArch Security

- Approach in two different phases
- First phase: ETCP (Entity Title Control Protocol)
  - Entity Based Security
  - Assessment of threats and counter-measures regarding each protocol primitive
  - Data Plane Security Issues (this has a strong connection to requirements)
- Second Phase: DSTCP (DTS Control Protocol)
  - DTSA based security

“The era of brute force based security is over”, Pedro Frosi Rosa.