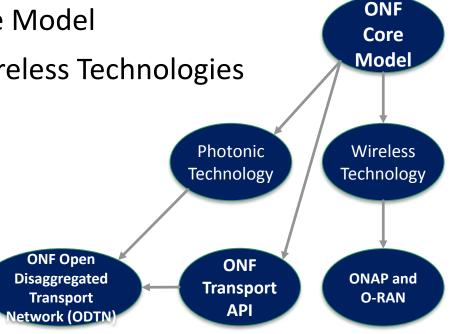


### 5G RAN and Wireless xHaul (formerly WTP) Modeling, Testing, and Implementation in collaboration with O-RAN and Linux Foundation

Contributors (in alpha order; speakers' names underlined) Giorgio Cazzaniga - SIAE Thorsten Heinze - Telefonica Petr Jurcik – Deutsche Telekom Lyndon Ong – Ciena Martin Skorupski - highstreet Tracy van Brakle – AT&T

### **ONF SDN Models**

- Development of the ONF Core Model
- Extension to Photonic and Wireless Technologies
- Implementation and Testing





## **Modelling SDN**

The Core model provides a standardized implementation-neutral representation of things and the relationship between those things in the SDN problem space

- Network functions. *Model focus*:
  - Virtualized termination/forwarding in any network
- Physical Equipment supporting the network. *Model focus*:
  - Field Replaceable Units (FRUs), non-FRUs, strands etc.
- Control functions supporting the network. *Model focus*:
  - Representation of functions related to closure of control loops
  - Presentation of views of the resources for the purpose of control
- Processing functionality supporting/using the network. *Model focus*:
  - Any abstract function
- Resource/System/Scheme specifications. *Model focus*:
  - Constraints, rules and specs for the overall systems
- Software supporting the control
  - Files, Installed Software, Containers, VMs,

Most recent focus has been on Analogue Guided Media networks, using photonic networks as the key application.

TR-512.A.4 provides the explanation of the use of the Core Model for photonic networks.

This work has been used extensively by OTCC and Facebook TIP



### Model to create a common language

- Goals:
  - A well defined widely applicable representation of the *semantics* of managed network functionality that is *lightweight*, has a *modular* architecture and is technology/technique *agnostic*
  - Reduce the formation of overlapping inconsistent implementations which hinder overall progress
- Approach:
  - Leverage industry best-practices, patterns and tools to close the *model to implementation* round trip loop
  - Use Agile modelling methodology to construct a formal model using Parameters
    - A graphical modeling language highlights underlying patterns
    - The environment provides a framework for:
      - Development of understanding about control of networks
      - Capturing a representation of the understanding
      - Maintaining growing insight
  - Promote Core Model use/extension
- Use:
  - Derivation of Interface/database models using generators to generate consistent artefacts in JSON, Yang etc.



Perspective

Model

Toolbars

Property View

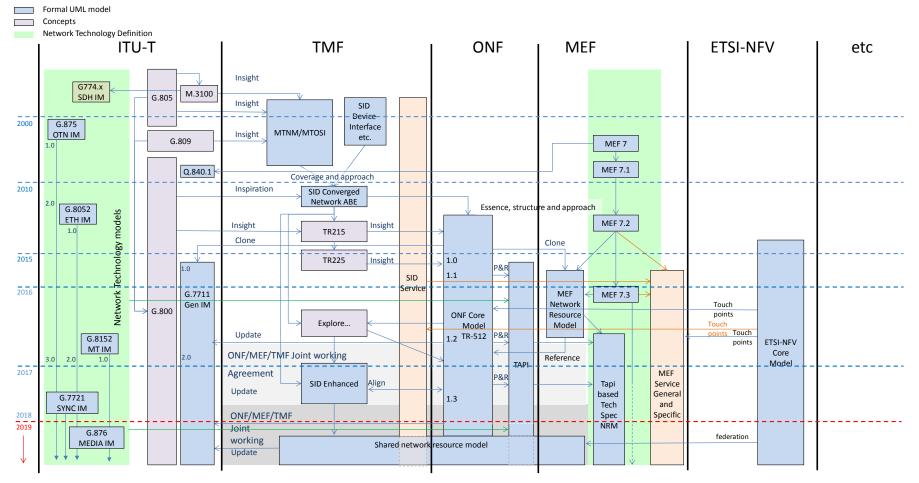
Project Explorer

Model

Explorer

Outline View

#### Information Model evolution



### Core Model: TR-512 v1.4

MACOSX

TR-512\_v1.4\_OnfCorelm-info ModelDescriptions

A suite of description documents and XMI • encoded UML constructs and diagrams.

- TR-512 v1.4
- MACOSX
- ▼ TR-512\_v1.4\_OnfCorelm-info
  - ModelDescriptions
  - OnfModel
- UmlFigures
- TR-512 v1.4 OnfCorelm-info.zip
- final source
- l old
- old
- v1.4.1
- \_v1.5

Name	

#### .project

- CoreCommonDataTypes.di CoreCommonDataTypes.notation p-
- CoreCommonDataTypes.uml 1-1

Type

DI File

UML File

UML File

UML File

UMI File

DI File

DI File

DI File

**PROJECT File** 

- CoreModel.di B--/ CoreModeLnotation
- 1-1 CoreModel.uml
- Experimental.profile.di
- Ber Experimental.profile.notation
- 1-1 Experimental.profile.uml
- OpenModel\_Profile.profile.di
- -OpenModel\_Profile.profile.notation
- VpenModel\_Profile.profile.uml
- OnfModel UmlFigures TR-512\_v1.4\_OnfCoreIm-info.zip final source l old old \_v1.4.1 v1.5 TR-514\_515\_531\_guidelines zip\_RE\_ Request for granting copyrights fo NOTATION File S. DT-IM NOTATION File presentation publication ΓΑΡΙ NOTATION File **Femplate** NT /\_MEF NOTATION File rip\_RE\_ Request for granting copyrights for

^	Name Name
	TR-512.2_OnfCoreIm-ForwardingAndTermination.pdf
	TR-512.3_OnfCoreIm-Foundation.pdf
	🚡 TR-512.4_OnfCorelm-Topology.pdf
	🚡 TR-512.5_OnfCorelm-Resilience.pdf
	🛃 TR-512.6_OnfCoreIm-Physical.pdf
	🚰 TR-512.7_OnfCorelm-Specification.pdf
	불 TR-512.8_OnfCoreIm-Control.pdf
	🚡 TR-512.10_OnfCorelm-InteractionPatterns.pdf
	🛃 TR-512.11_OnfCoreIm-ProcessingConstruct.pdf
	🚡 TR-512.12_OnfCoreIm-Software.pdf
	🛃 TR-512.A.1_OnfCorelm-AppendixOverview.pdf
	🛃 TR-512.A.2_OnfCoreIm-Appendix-ModelStructurePatternsAndArchitecture.p
	🛃 TR-512.A.3_OnfCoreIm-Appendix-ModelRationale.pdf
	🛃 TR-512.A.4_OnfCoreIm-Appendix-AnalogueAndMediaExamples-L0.pdf
or	🛃 TR-512.A.5_OnfCoreIm-Appendix-CircuitSwitchedExamples-L1-L2.pdf
01	🛃 TR-512.A.6_OnfCoreIm-Appendix-PacketSwitchedExamples-L2-L3.pdf
	🛃 TR-512.A.7_OnfCoreIm-Appendix-ControlAndInteractionExamples.pdf
	🛃 TR-512.A.8_OnfCoreIm-Appendix-TimingAndSynchronizationExamples.pdf
	🛃 TR-512.A.9_OnfCoreIm-Appendix-ProcessingConstructExamples.pdf
	TR-512.A.10_OnfCoreIm-Appendix-SpecificationExamples.pdf
	🛃 TR-512.A.11_OnfCoreIm-Appendix-ResilienceExamples.pdf
	TR-512.A.13_OnfCoreIm-Appendix-SoftwareExamples.pdf
	R-512.DD_OnfCoreIm-DataDictionary.pdf
	TR-512.FE_OnfCoreIm-FutureEnhancements.pdf
	R-512.GT_OnfCoreIm-CommonGendocTemplate.pdf
٢L	嶎 TR-512.TM_OnfCorelm-TerminologyMapping.pdf

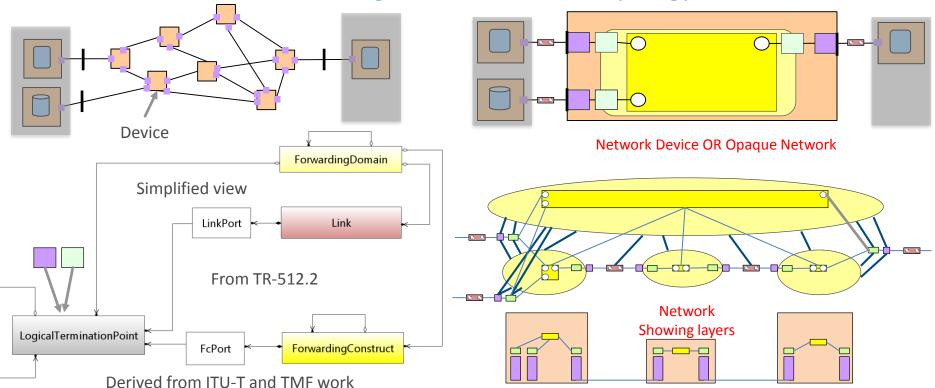


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#### Canonical network model (virtualized/functional):

See slide notes

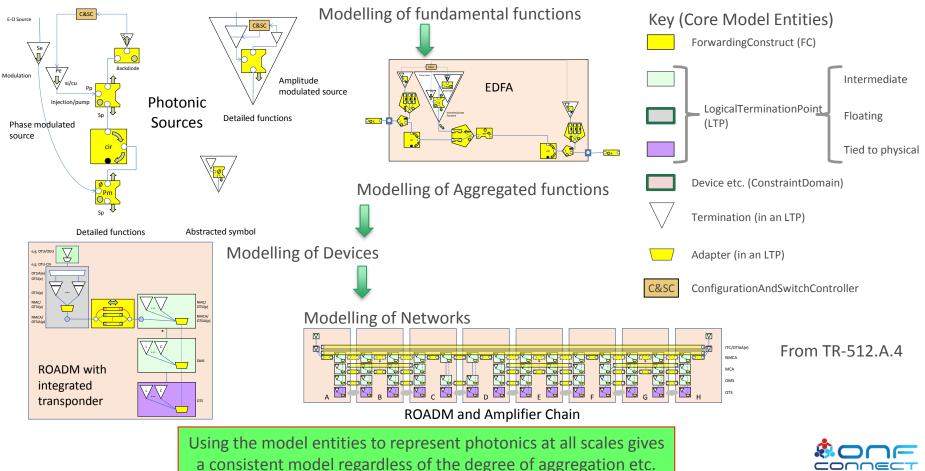
#### Forwarding, Termination and Topology



Model for any networking, for any network technology, with any degree of virtualization, at any scale, at any abstraction and in any interrelated view.

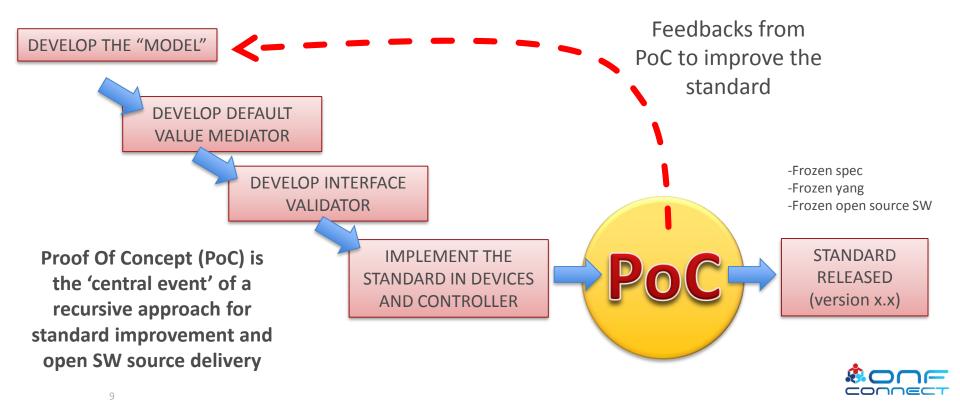


### Photonic network analysis and modeling



PoCs & plugfests followed by pilots and/or PIZ (Production Innovation Zone)

#### PoC AS FUNDAMENTAL STEP OF 'IMPLEMENTATION DRIVEN STANDARD'

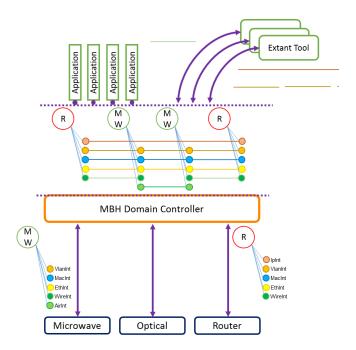


#### PoC = ONAP (ODL) WIRELESS CONNECTED DEVICES (AS EXAMPLE)

				Nodes: % 25    Al	arm status: 📥 4   🔺 8   🔺 2   🕯	20   Sum: 34 🔮 Help		
<ul> <li>Required network eler</li> </ul>	nents							
V Name 🔺	<ul> <li>Connection status</li> </ul>	IP address	Port ~ Client	<ul> <li>Actions</li> </ul>		~ =		
	C CONTROLOGY				U I U A F	3		
Ceragon-A	% connected	172.29.145.4						
					🖌 🖋 Connect			
Cragon-B	% connected	172.29.145.4	1 Yang UI					
☑ <sup>®</sup> Ericsson-A	% connected	172.29.145.39	Connect	Required network elements				
I Ericsson-Z	% connected	172.29.145.39						
HUAWEI-136	% connected	172.29.145.40		V Name 🔺	<ul> <li>Connection status</li> </ul>	P address V	Port ~	Client
HUAWEI-137	% connected	172.29.145.40						
C Infinera_groove-A	% connected	172.29.145.182	JONAP SO	C <sup>*</sup> MW11Phy-3	% connected	172.29.145.35	12003	172.29.145.7
	-		A Fault	I2 NEC-91	% connected	172.29.145.150	830	172.29.145.7
✓ Infinera_groove-B	% connected	172.29.145.183	<sup>3</sup> 🔑 Maintenance	⊡ <sup>*</sup> NEC-92	% connected	172.29.145.151	830	172.29.145.7
Intracom-Hi	% connected	172.29.145.139	Configuration	☑ Nokia-Wavence-144	% connected	172.29.145.144	830	172.29.145.7
C <sup>*</sup> Intracom-Lo	% connected	172.29.145.138	Protection	☑ Nokia-Wavence-145	% connected	172.29.145.145	830	172.29.145.7
MW11Phy-1	% connected	172.29.145.3	5 Laul PM Current	Z SIAE-148-ECDSA	% connected			
Total Items: 25			M History	LS SIAE-146-ECDSA	% connected	172.29.145.240	33001	172.29.145.7
			M Link	IZ SIAE-149-ECDSA	% connected	172.29.145.242	33002	172.29.145.7
			C Security	✓ IZ SMO-NE113	% connected	172.29.145.174	8300	172.29.145.7
			Inventory	COND NEW	% connected	172.29.145.175	8300	172.29.145.7
				2 ZTE-141	% connected	172.29.145.43	2440	172.29.145.7
			Topology		-			
			Emergency	C <sup>*</sup> ZTE-142	% connected	172.29.145.43	2340	172.29.145.7

#### PILOT = 5G xHaul Network Automation

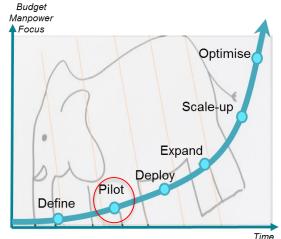
- Automation requires end2end network representation, which consolidates all device types, all vendors and OSI layers 0-4 in a single network topology
- Ceragon, Deutsche Telekom, Ericsson, Huawei, Infinera, Nokia, SIAE Microelettronica and Telefonica commonly defined <u>a set of</u> <u>complementary information models based on the ONF Core</u> <u>IM:</u>
  - Wire Equipment (SFP handling)
  - Radio Interface (ONF TR-532)
  - Wire Interface (based on IEEE 802.3)
  - Ethernet (incl. Queueing, Scheduling, Shaping)
  - Ethernet MAC
  - VLAN (based on IEEE 802.1Q-2018)
  - Basic IP Interface and Layer3VPN





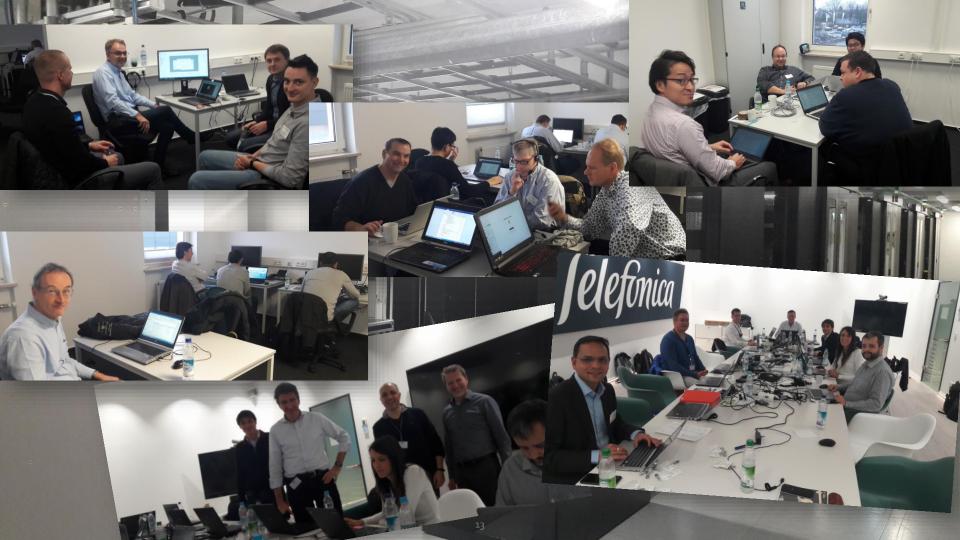
### Joint 5G-xHaul SDN Pilot

- AT&T, Deutsche Telekom and Telefonica are inviting Operators for parallel execution of SDN tests, trials and pilots
- Newly defined information models shall be tested
- Components (e.g. mediators, applications) will be re-used and know-how will be shared
- Individual, live network testing (instead of PoC) conforms with increased maturity of the technology and fosters deeper involvement of participating organizations
- Software Providers are invited to present own Applications based on the common information models at participating Operators

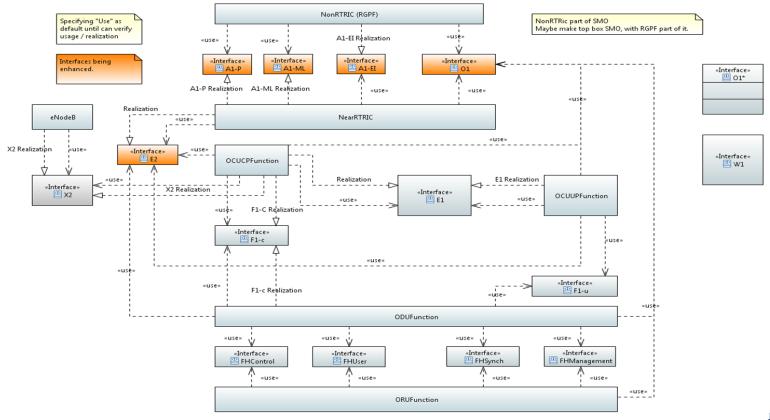




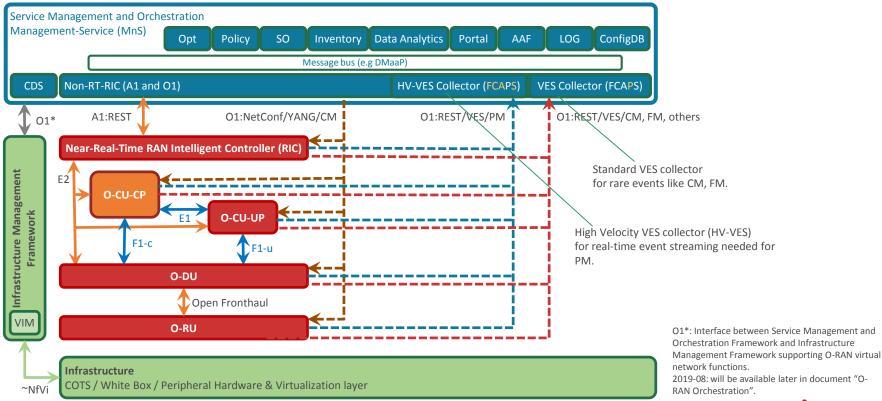




## O-RAN component diagram for 5G RAN (3GPP++)



## ONF + O-RAN + ONAP (as SMO) integration





#### **Proposed use cases for ONF / LFN PoC week of December 2<sup>nd</sup> 2019**\*

#### Physical Network Function (PNF) Plug and Play (PnP)

https://wiki.onap.org/pages/viewpage.action?pageId=40206485

PM Bulk request

https://wiki.onap.org/pages/viewpage.action?pageId=40206494

- Basic fault
- Basic configuration
  - Read
  - Write
- OOF-based 5G SON use cases

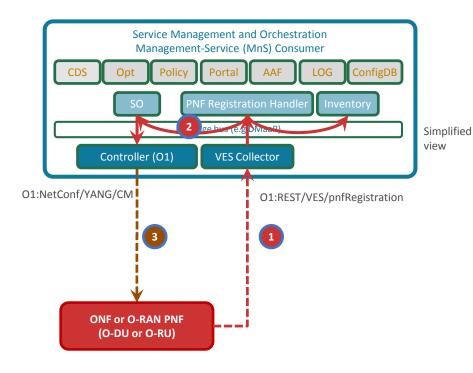
Open topics:

- Dynamic VES subscription mechanism
  - Under discussion by O-RAN and 3GPP
  - Simplification for Demo: pre-configuration of the O-RAN PNF with necessary VES collector information (IP, credentials)



\* Coincides with first release O-RAN-SC "Amber" and ONAP rel 5 El Alto (may include add'l ONF entities)

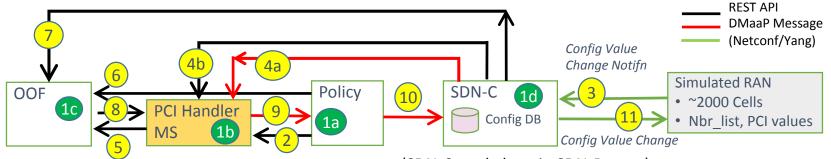
#### **PNF Plug and Play Message flow**



- 1. O-RAN PNF sends VES pnfRegistration preferred IPv6/TLS
- 2. Controller (O1) becomes awareness of the new O-RAN PNF via Message bus
- Controller (O1) checks NetConf end-point on the O-RAN PNF (hello-message) – preferred: IPv6/TLS



#### 5G SON use case example: PCI Optimization using OOF



(SDN-C work done in SDN-R team)

Step	Functionality
1a-1d	All modules loaded to support PCI
2	PCI-Handler MS fetches configuration policies from Policy
3	Config change notification from RAN to SDN-C (e.g. Nbr list change)
4a	SDN-C publishes config data change on DMaaP to PCI-Handler-MS.
4b	PCI-Handler MS obtains relevant info from SDN-C (REST API call)
5	PCI-Handler MS invokes OOF for pre-defined workflow for PCI Optimization (REST API call)

Step	Functionality
6	OOF gets PCI optimization policies from Policy
7	OOF queries SDN-C database to fetch data for cells in the region (REST API call)
8	OOF provides PCI Optimization result to PCI Handler MS (REST API call)
9	PCI-Handler-MS provides PCI recommendation to Policy on DMaaP
10	Policy sends message to SDN-C with instruction for PCI configuration changes on DMaaP
11	SDN-C applies config changes via Netconf



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#### **Issues and next steps (a partial list)**

- Ongoing efforts to maintain consistency among IM, UML, and YANG (this is non trivial!)
- Reconcile open information models across multiple open source projects, e.g. ONF, ONAP, O-RAN (one can have too many models!)
- Prosumer" relationships among open source projects and SDOs, as one is expected to provide/consume the other's work products (and vice versa)





# Thank You

https://www.opennetworking.org/open-transport/

www.o-ran.org

www.onap.org

www.o-ran-sc.org