A World Leading SFI Research Centre

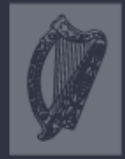
Trinity College Dubli
Coláiste na Tríonóide, Baile Átha Clia
The University of Dublin

CONNECT
Centre for Future Networks

CONNECT's view on virtualisation: Testbeds, experimentation and future plans

Marco Ruffini

Trinity College Dublin
The University of Dublin



Ireland's European Structural and Investment Funds Programmes 2014-2020
Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

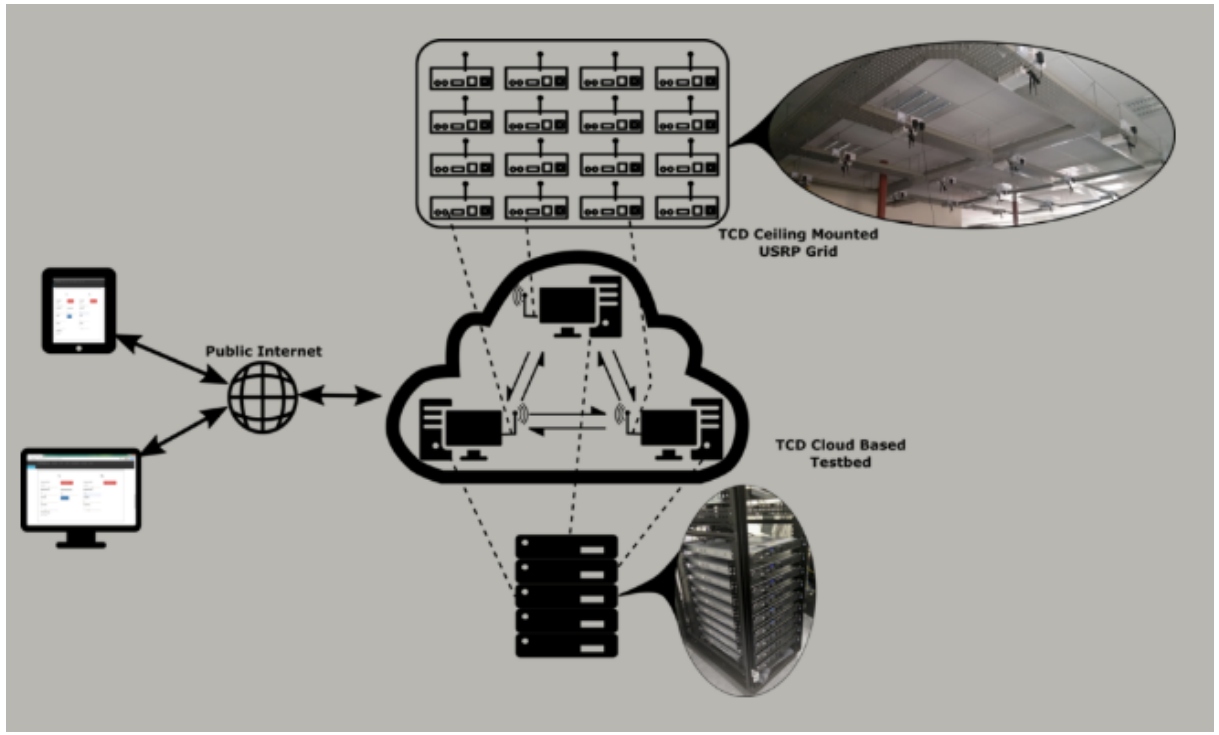
Science Foundation Ireland
sfi For what's next

Summary

- TCD wireless virtualisation testbed
- TCD optical virtualisation testbed
- The optical-wireless integration: variable rate fronthaul use case
- Future plans

Iris - reconfigurable testbed architecture @ CONNECT, Trinity College Dublin

Trinity College
The University of Dublin

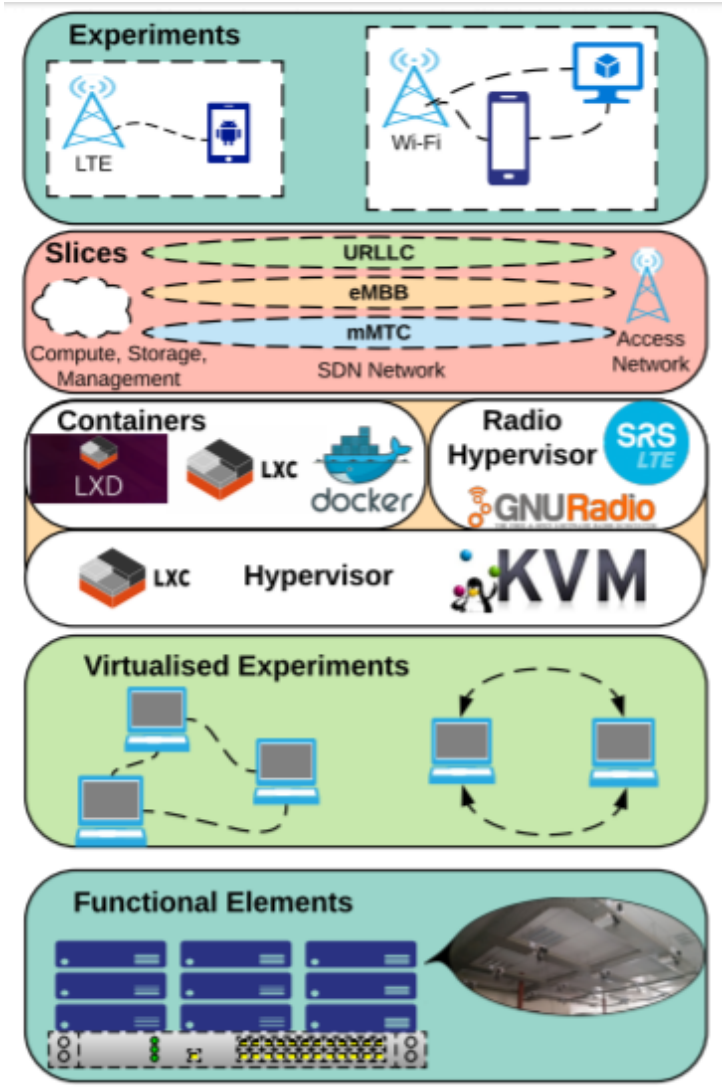


1. 20+ USRPs
2. Cloud based virtual machines
3. Open access all over the world through Fed4FIRE project

More information: https://iris-testbed.connectcentre.ie/

CONNECT
Networks of the Future

Network virtualisation in wireless testbed

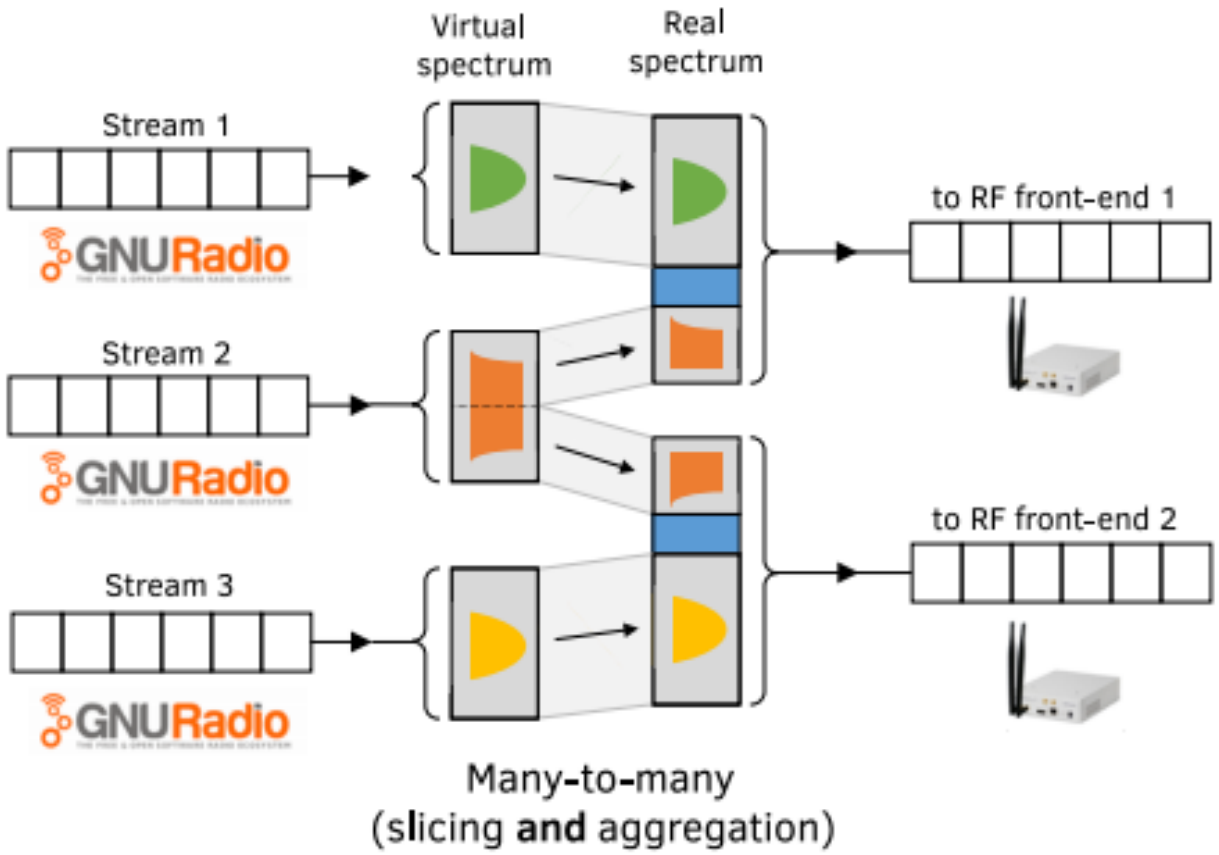


Virtualisation layer, from top to down

1. Experiments (internal & external access)
2. Experimental slices
3. Virtualised containers & Virtual machines
4. Virtualised Experiments
5. Functional elements - hardware

Slicing, virtualisation, and aggregation

- GNU-Radio module that can do both spectrum slicing and aggregation
- Many users to many resources
- Flexibility:
  - Any virtual and real spectrum sizes
  - Separate isolation and mapping
  - Non-contiguous spectrim assignment possible



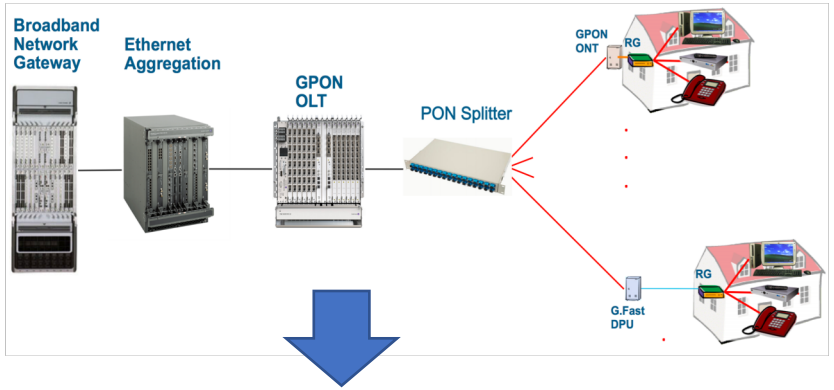
Summary

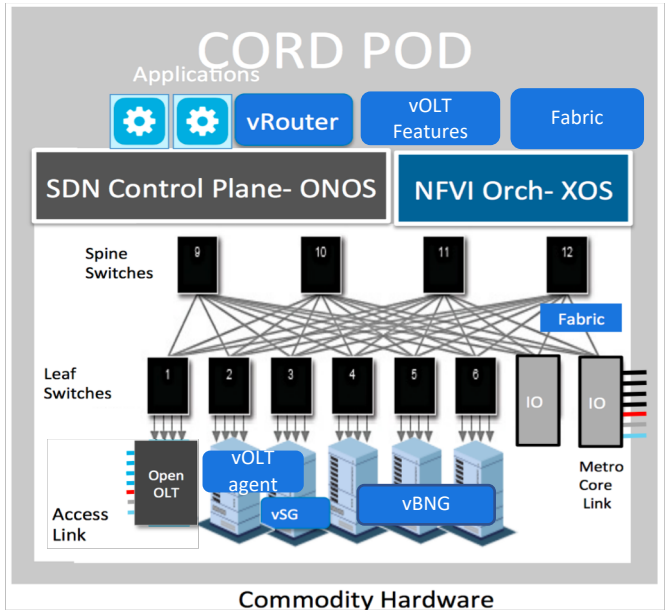
- TCD wireless virtualisation testbed
- TCD optical virtualisation testbed
- The optical-wireless integration: variable rate fronthaul use case
- Future plans

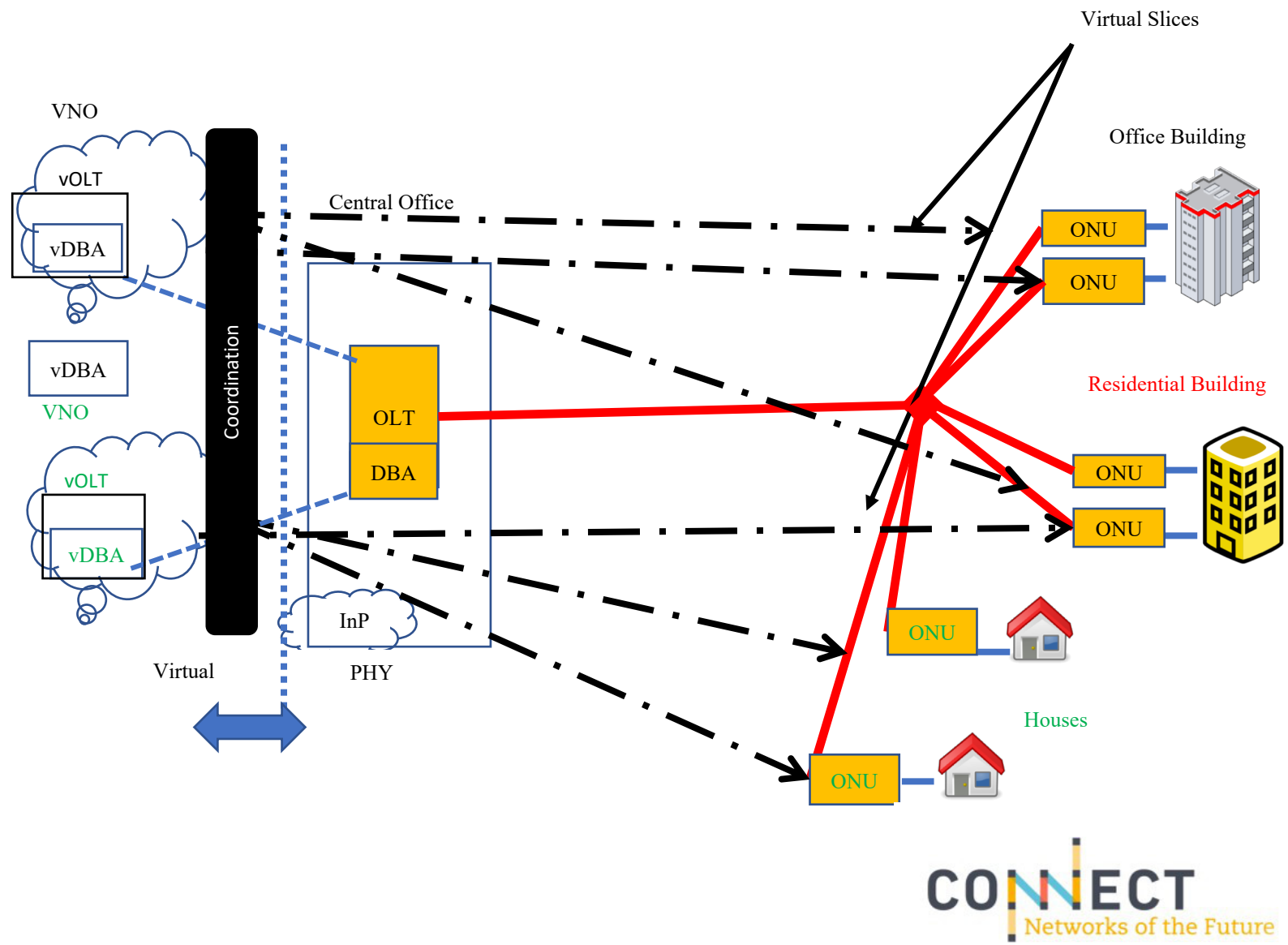
True Passive Optical Network Multi-Tenancy

Trinity College
The University of Dublin

Central Office re-architected as a data centre (CORD)

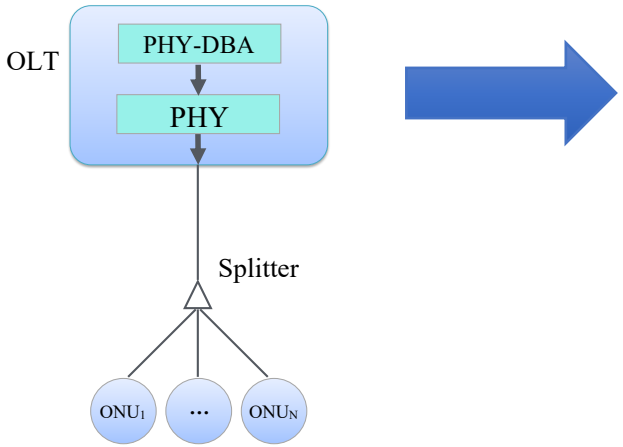




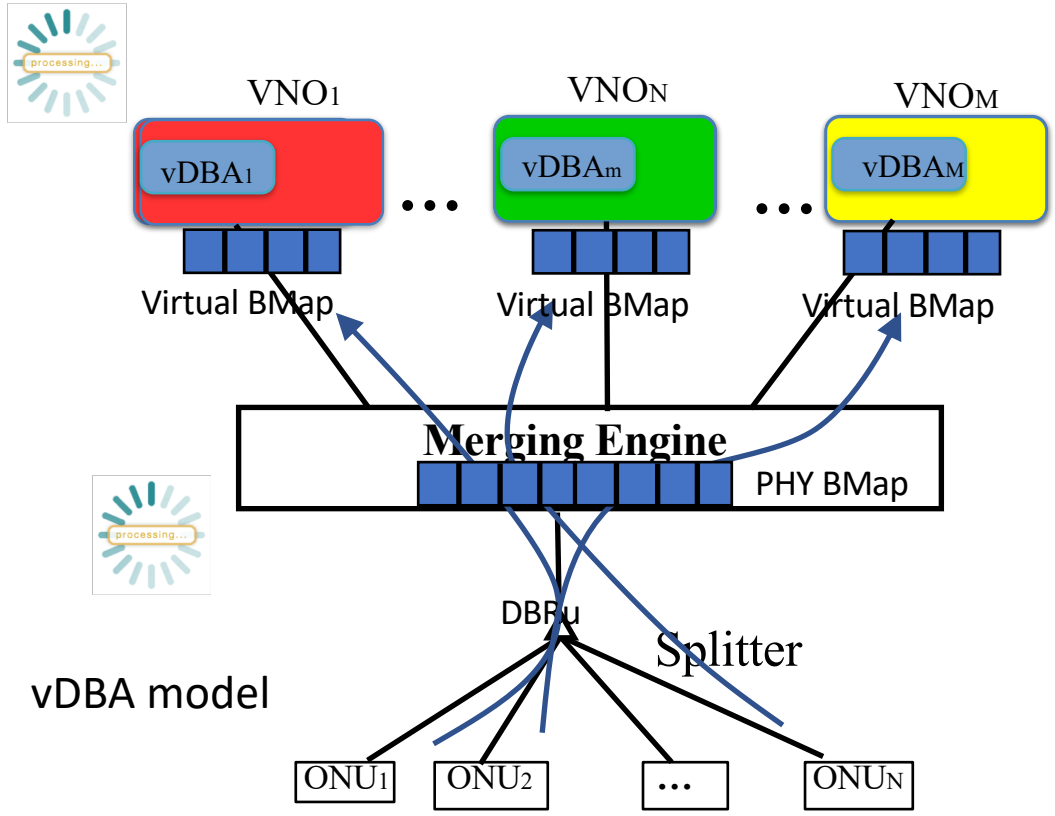


CONNECT
Networks of the Future

Full disaggregation of the OLT



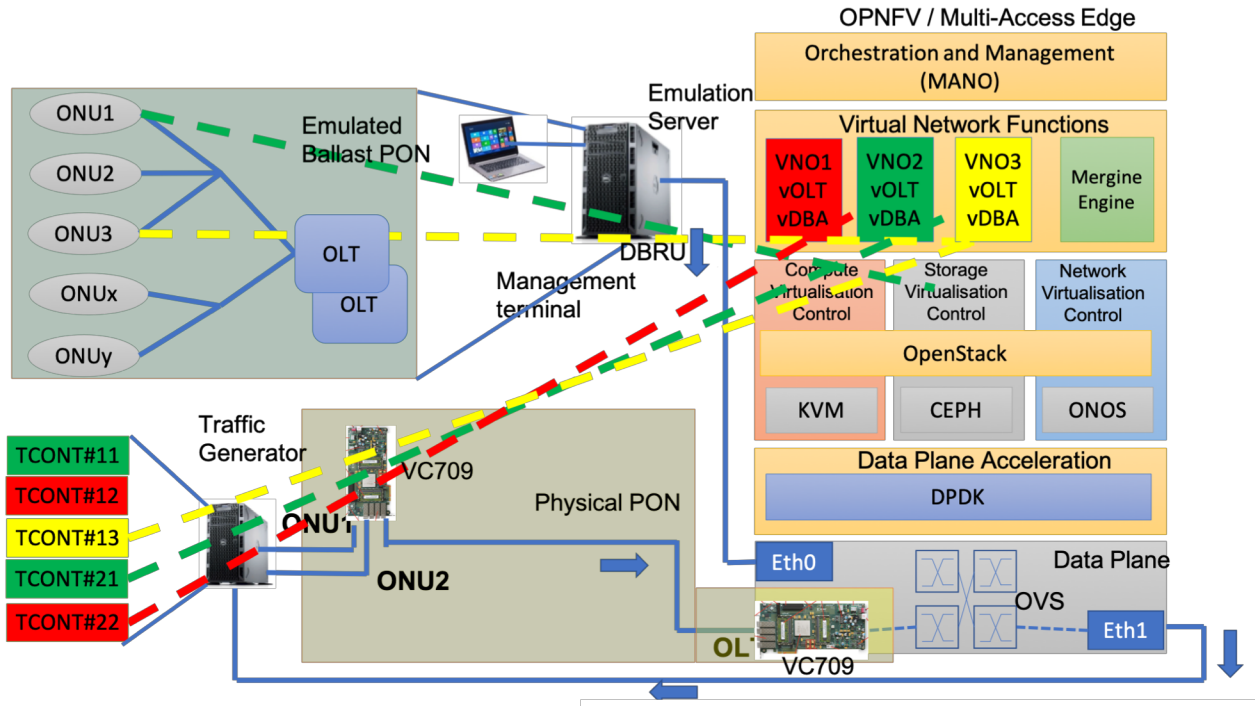
Current physical DBA model



vDBA model

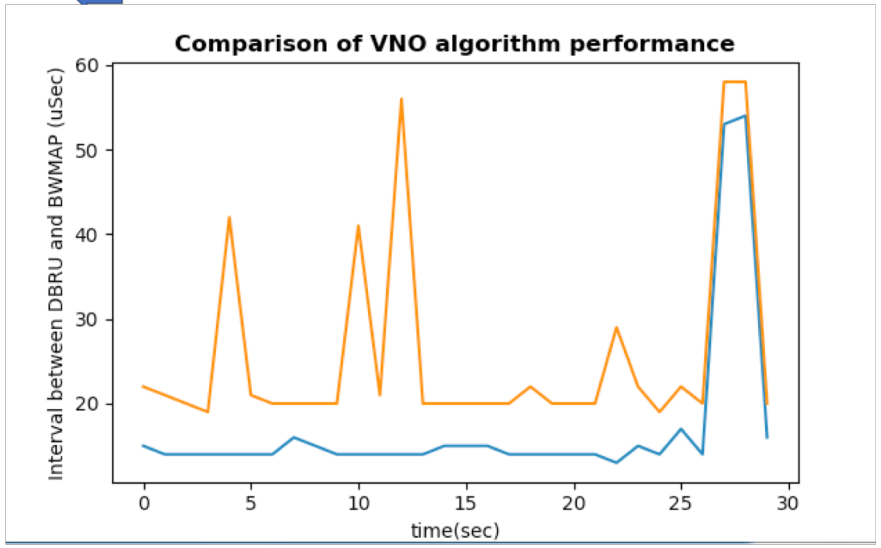
- Work on DBA virtualization to enable fine-grained control to different tenants.
- Also other use cases: e.g., for service differentiation, for mobile front haul (more on this later)
- Both recently included in BBF TR-402 “PON Abstraction Interface for Time-critical Applications”

Implementation and results

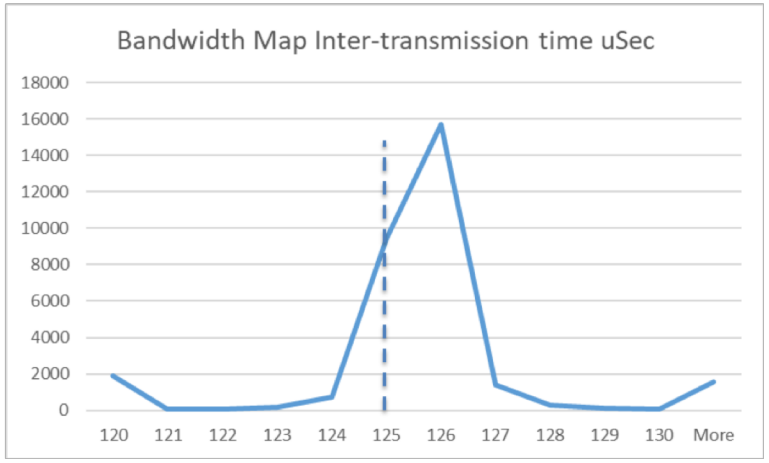


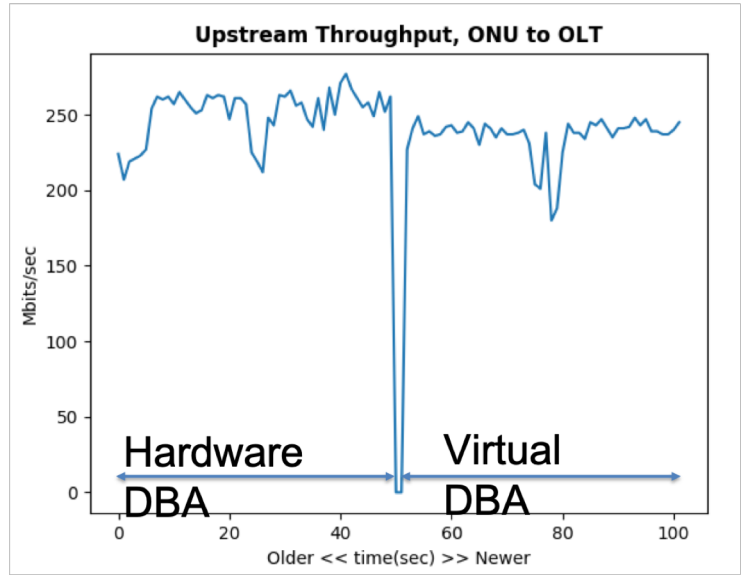
Running two DBA scheduling algorithms:

- one VNO looking for high efficiency,
- one VNO looking for low latency



Timing performance

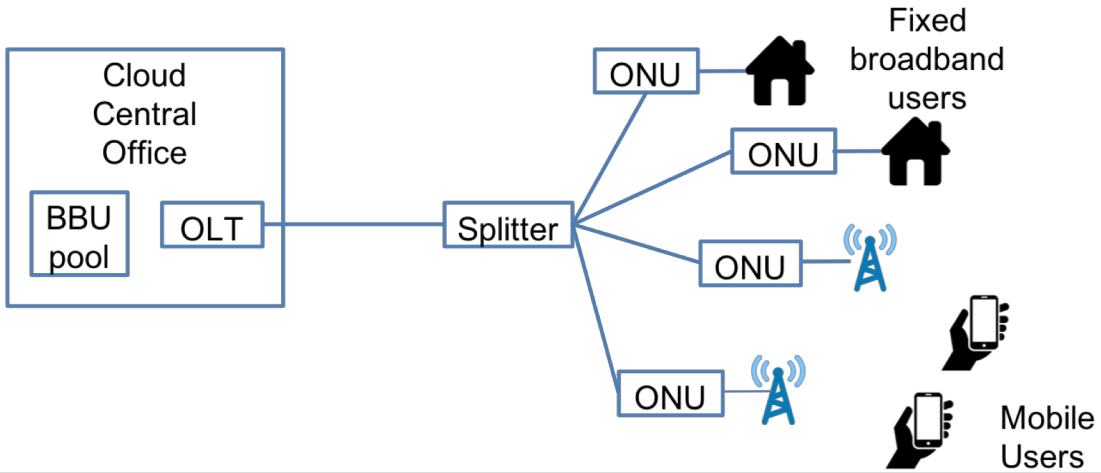




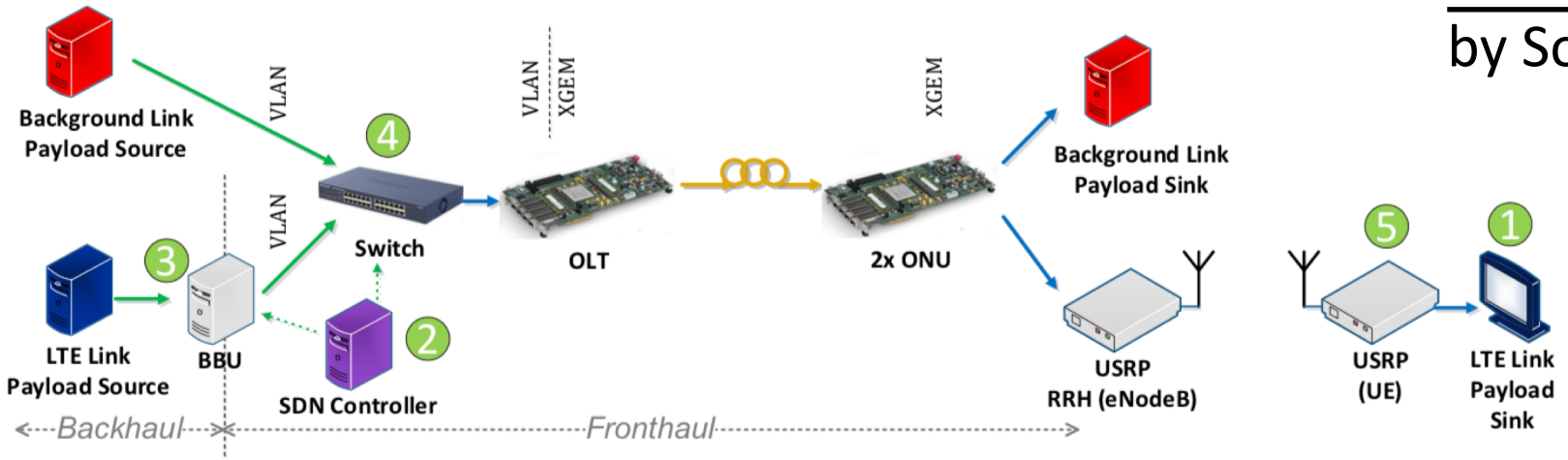
Summary

- TCD wireless virtualisation testbed
- TCD optical virtualisation testbed
- The optical-wireless integration: variable rate fronthaul use case
- Future plans

Optical-wireless convergence: Variable rate fronthaul



- **First** variable-rate fronthaul implementation on converged optical-wireless testbed, with SDN control.
- **First** variable-bandwidth adjustment implementation on a LTE standard-compliant BBU pool by Software-defined Radio.

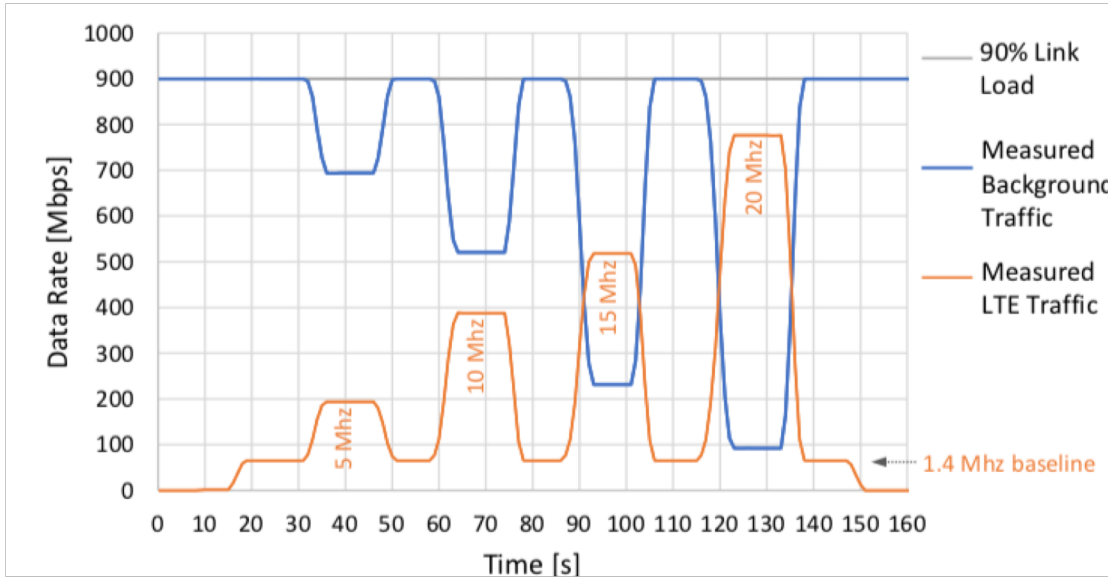


Events:

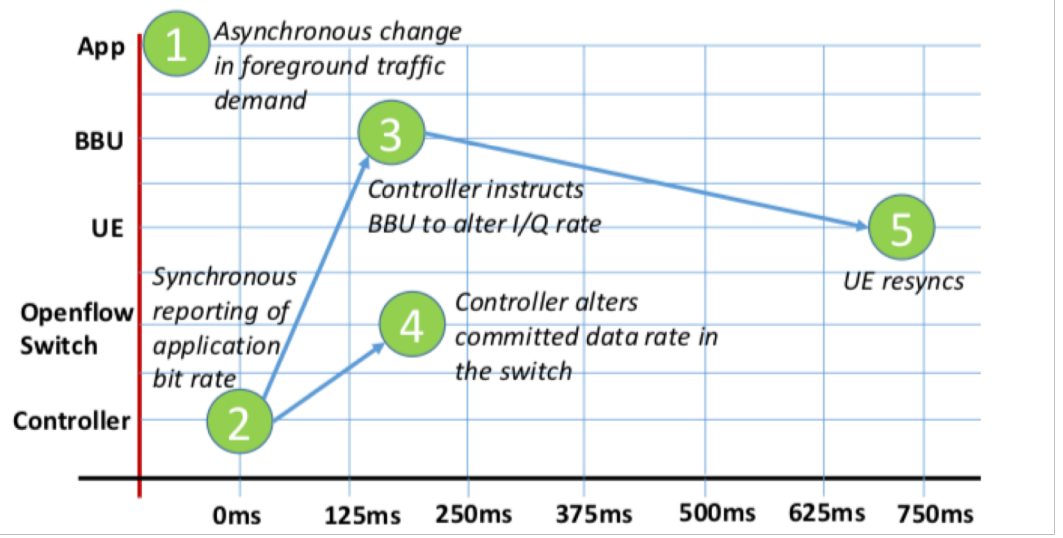
1. *Asynchronous change in foreground traffic demand*
2. *Synchronous reporting of application bit rate*
3. *Controller instructs BBU to alter I/Q rate*
4. *Controller alters committed data rate in the switch*
5. *UE resyncs*

1G Ethernet
10G Ethernet
Fibre

Experimental Results



Measured fronthaul vs. best effort traffic



Time diagram of switching events

Wireless Bandwidth	PRB Number	Fronthaul Rate	Max Cell Capacity
1.4 MHz	6	61 Mbps	1.8 Mbps
3 MHz	15	121 Mbps	4.584 Mbps
5 MHz	25	182 Mbps	7.736 Mbps
10 MHz	50	364 Mbps	15.264 Mbps
15 MHz	75	485 Mbps	22.92 Mbps
20 MHz	100	730 Mbps	30.576 Mbps

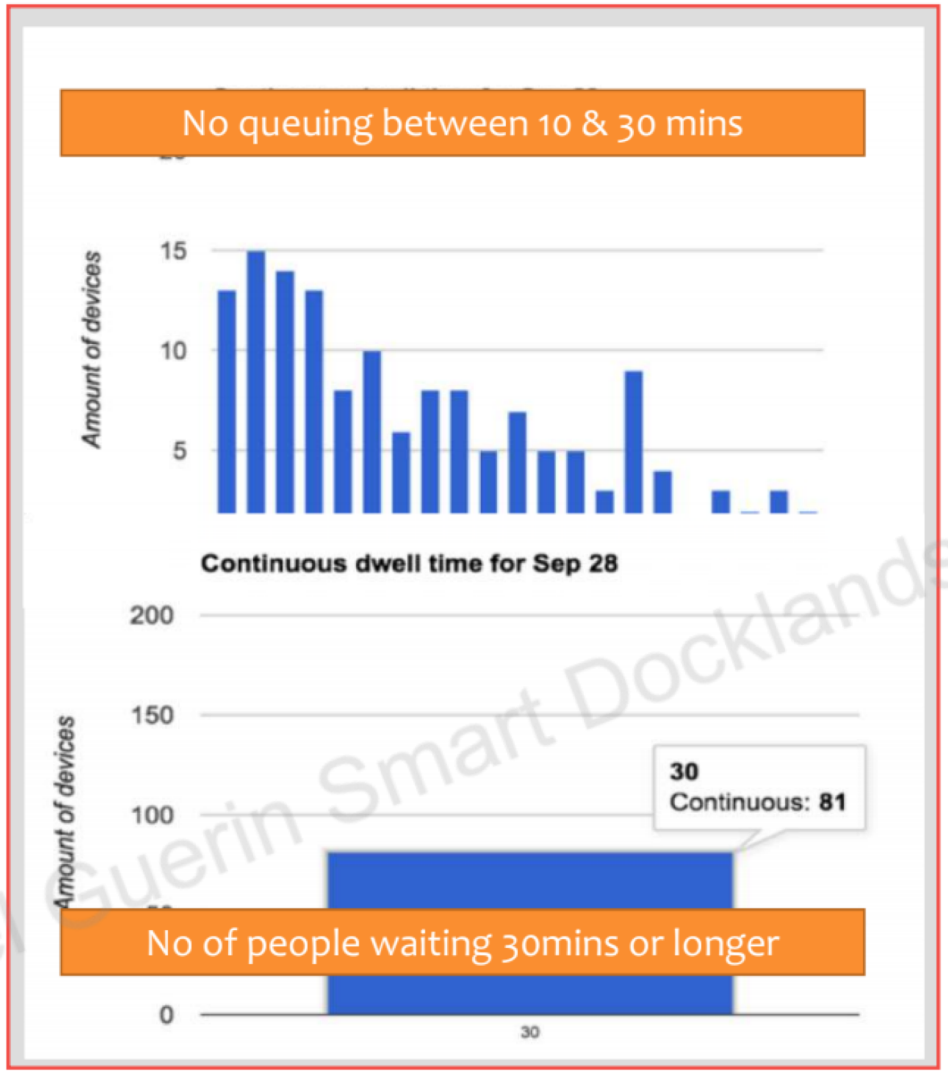
[1] Alvarez, P., Slyne, F., Blumm, C., Marquez-Barja, J., DaSilva, L., & Ruffini, M. (2018, March). Experimental Demonstration of SDN-controlled Variable-rate Fronthaul for Converged LTE-over-PON. In *Optical Fiber Communication Conference* (pp. Th2A-49). Optical Society of America.

Summary

- TCD wireless virtualisation testbed
- TCD optical virtualisation testbed
- The optical-wireless integration: variable rate fronthaul use case
- Future plans

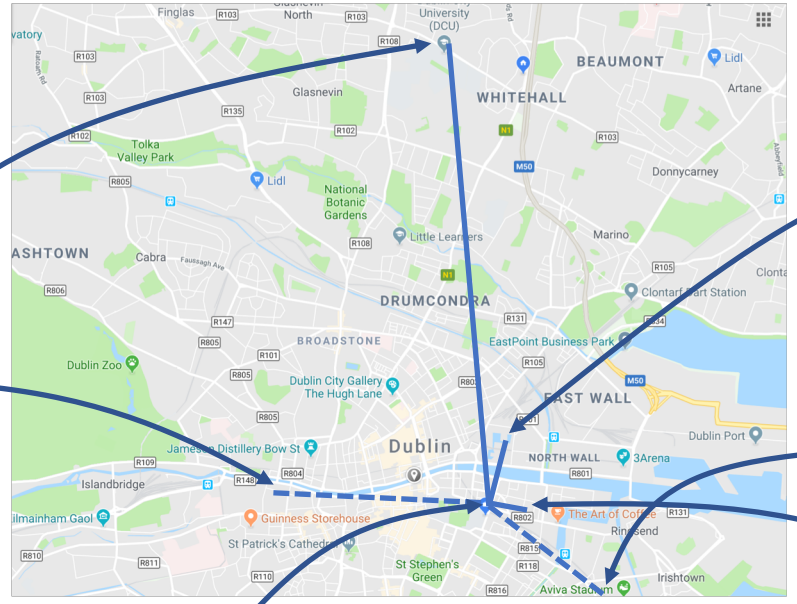

SMART DOCKLANDS
A Smart Dublin District
+€3 BILLION
OF NEW INVESTMENT UP TO 2020
26,000 RESIDENTS
HOME TO OVER 500 BUSINESSES
44,000 EMPLOYEES
COVERING AN AREA OF JUST 3 KM²
Success Stories
Smart Mobility
Smart Environment
Smart Infrastructure
Smart Buildings
Smart People
Smart Economy
Dublin Port
THE MOST CONNECTED DISTRICT IN THE WORLD
LORA, SIGFOX, NB-IOT, 4G, 5G

Analysis of queue times 28th September 2017



Future plans

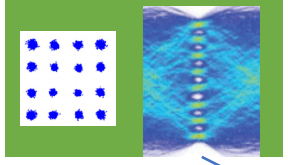
THE DIGITAL HUB



HEAnet
Ireland's National Education & Research Network

DCU

Multi-level & bandwidth variable transmission testing



mm-wave radio

Analogue RoF testbench

Leaf
Servers

ROADM

Outdoor macro cells

5 km dark fibre

TCD

ROADM
Optical fibre switch
WSS

200G
200G
Spine
Spine
Leaf
Leaf
Leaf
Leaf
Servers
Servers
Server
Server
Server
Server

Macro cells
Indoor+outdoor
P2P access
Small cells
Power split / WDM access

Software
- Amarisoft macro BBU
- Amarisoft EPC
- srsLTE small cell BBU
- srsLTE EPC

50 km
ROADM
ROADM
ROADM
ROADM
OSA
Scope
80-ch source

750 m dark fibre

Ttech

ROADM
Optical fibre switch
WSS

200G
200G
Spine
Spine
Leaf
Leaf
Leaf
Leaf
Servers
Servers
Server
Server
Server
Server

Macro cells
Indoor+outdoor
P2P access
Small cells
Power split / WDM access

Software
- Amarisoft macro BBU
- Amarisoft EPC
- srsLTE small cell BBU
- srsLTE EPC