



Fibre access virtualisation technology and evolution paths to MEC support

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Trinity
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The University of Dublin



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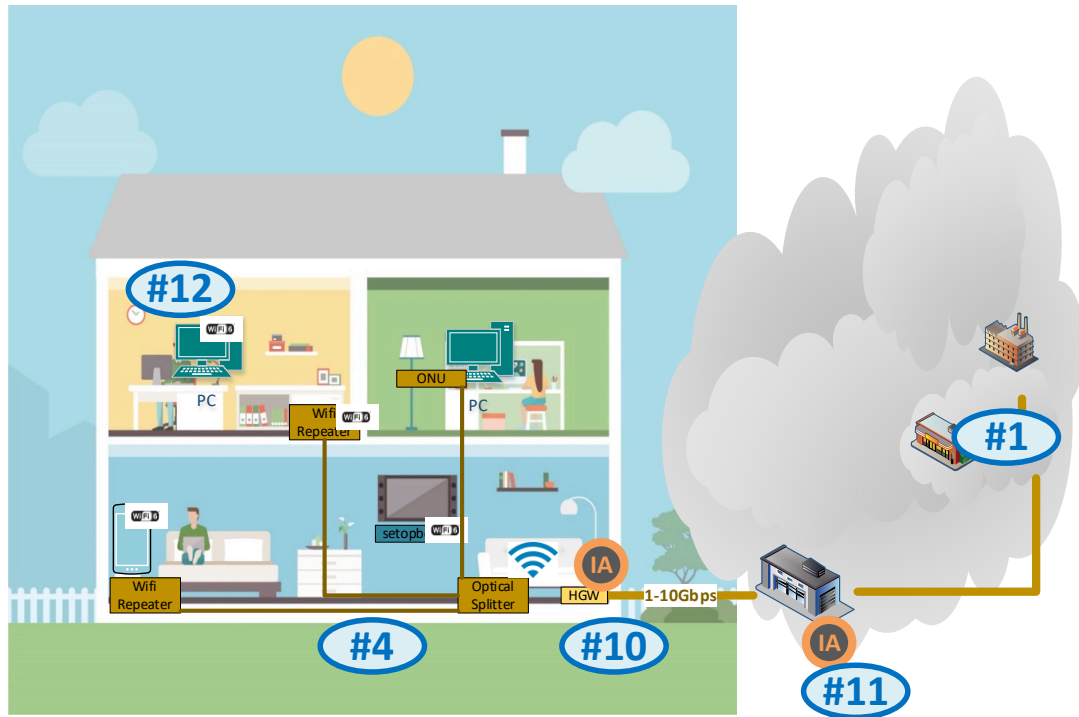
Co-funded by the Irish Government
and the European Union



ECOC
2020



Fifth Generation Fixed Network (F5G) sample cases



#1: Cloud Virtual Reality

#4: PON on-Promises

#10: Scenario based broadband

#11: Enhanced traffic monitoring and network control in Intelligent Access Network

#12: On Demand High Quality Transport for Real time applications

Enhanced Fixed Broadband (eFBB):

- increase BW Capability

Full-Fiber Connection (FFC):

- Increase density

Guaranteed Reliable Experience (GRE):

- Increase quality

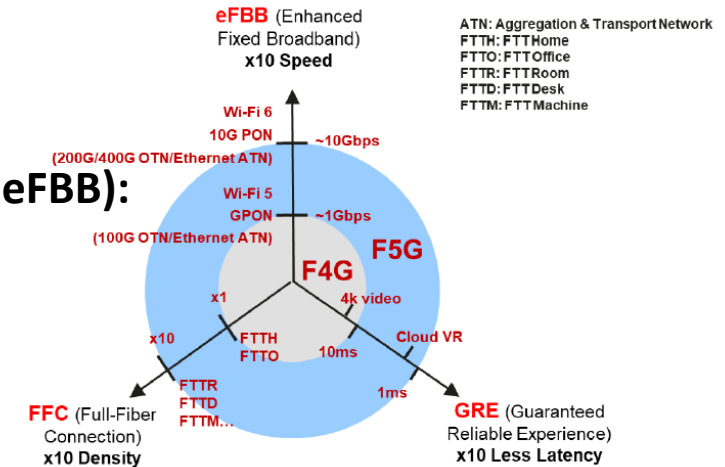


Figure 1: Features of F5G

https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp_41_FSG_ed1.pdf

What are we going to run on that network?

- Immersive participation in entertainment can be a game changer...
we are seeing great improvements in devices



- You can create your own avatar..
 - For this one uses a phone app called in3D.. and you can export it to other apps
 - Takes 10 seconds to do it.. But **all processing is done in the cloud**, before getting back to you.



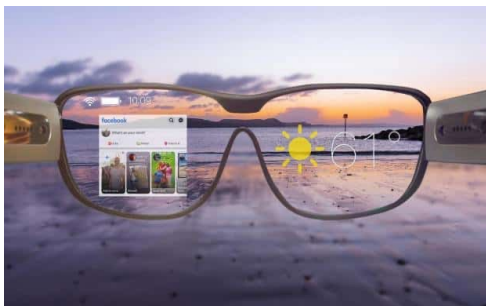
High performance VR today

- There is a large amount of computation, for which you need either external support... (cabled device)
- Or can do without PC and cable, sacrificing some performance
- Or wait for this...



Object recognition

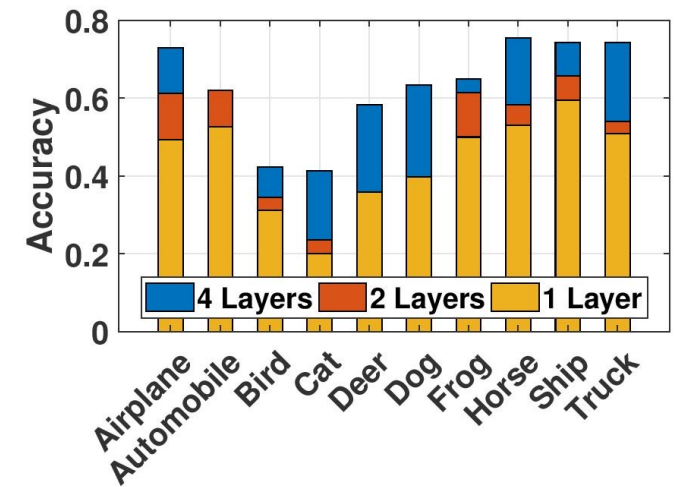
...and offload your computation elsewhere



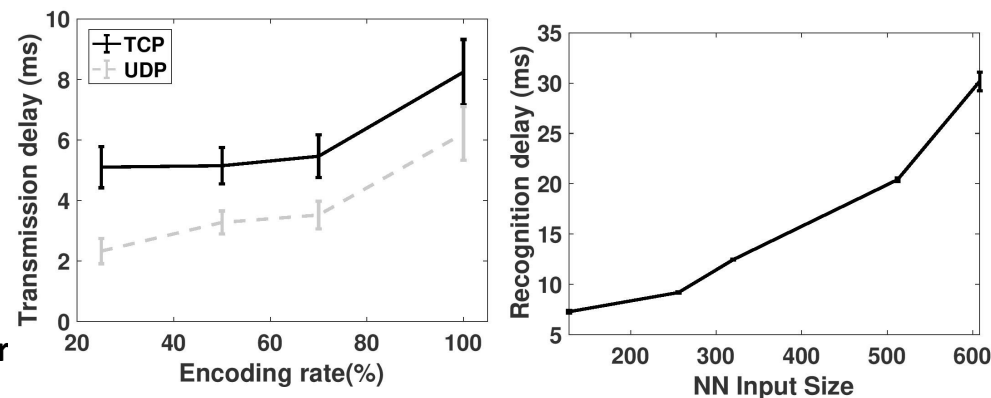
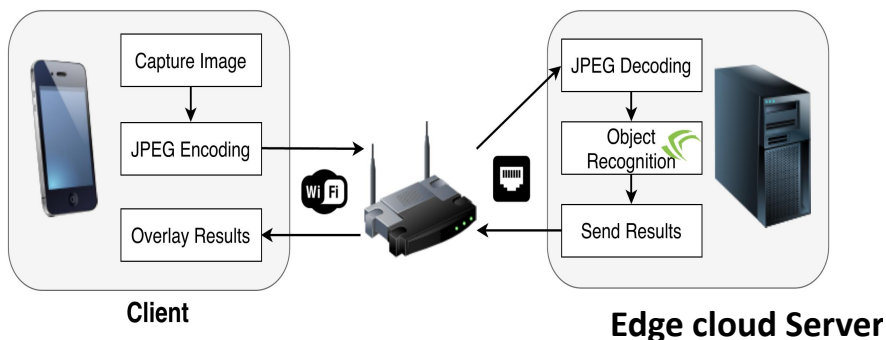
Offloading to the edge

There is much research happening now on removing heavy computation altogether, i.e. offloading computation to the edge.

- Example of object recognition



A. Galanopoulos, et al. Improving IoT Analytics through Selective Edge Execution, in proc. of IEEE ICC, 2020



Average Precision

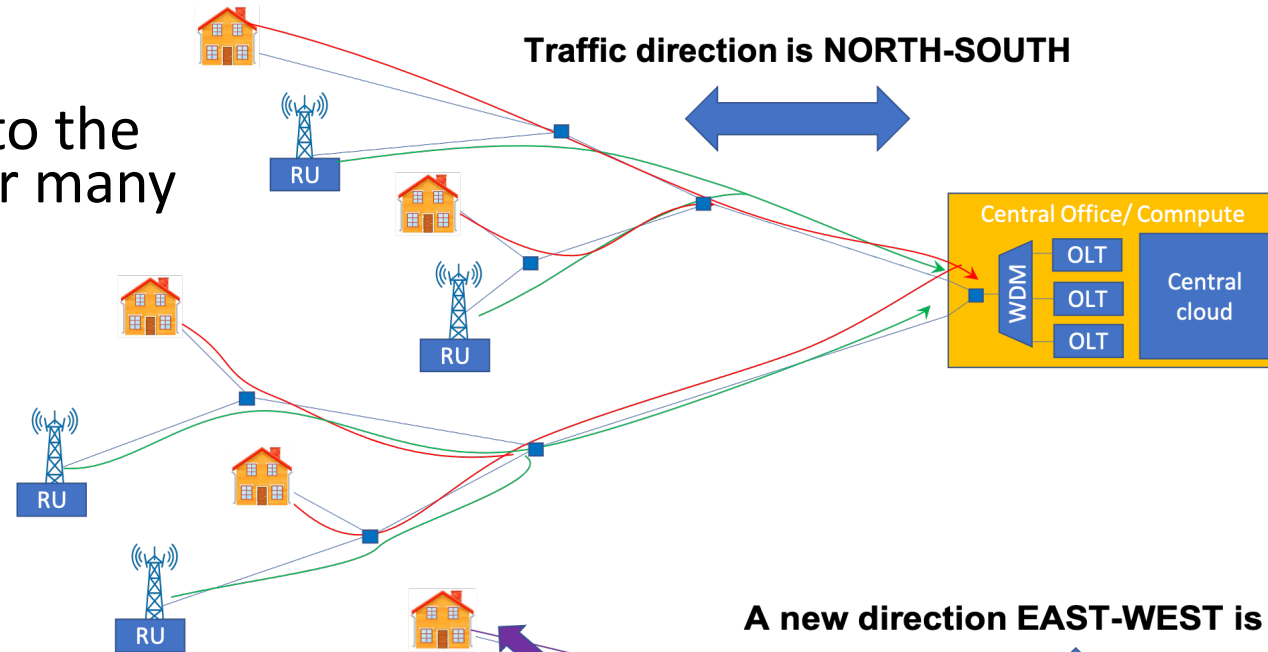
NN size	25	50	75	100
608	0.41	0.47	0.5	0.52
512	0.43	0.48	0.5	0.52
320	0.42	0.44	0.45	0.45
256	0.38	0.4	0.4	0.4
128	0.12	0.12	0.12	0.12

Encoding rate (%)

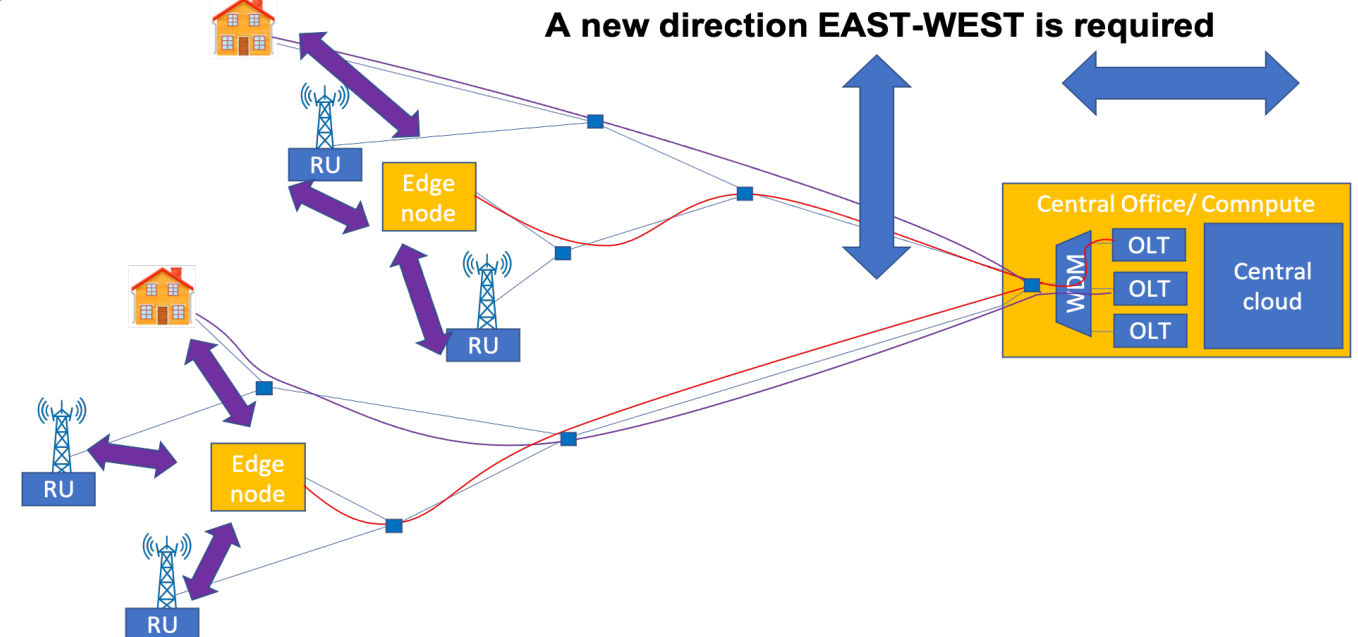
A. Galanopoulos, et al. Measurement-driven Analysis of an Edge-Assisted Object Recognition System, in proc. of IEEE ICC, 2020

The edge connectivity problem

- PONs can carry the info back to the central office and can work for many applications



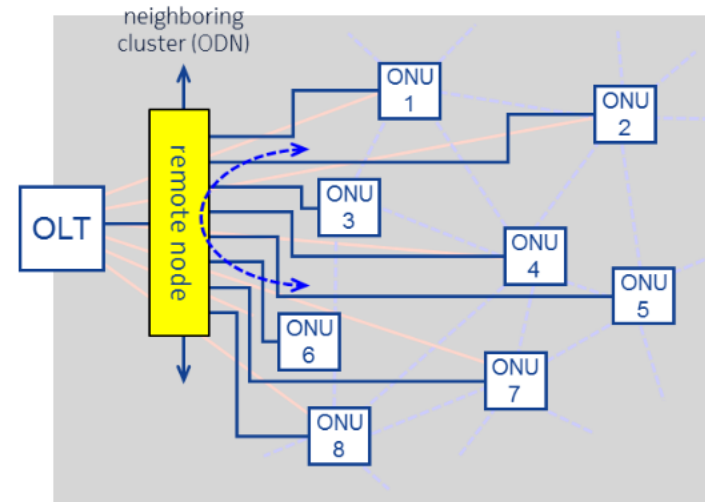
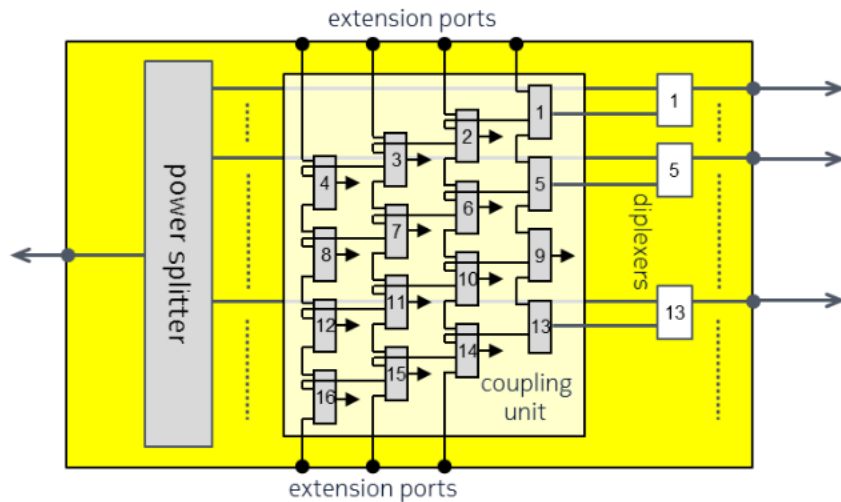
- For lower latency there are MEC nodes... that's why they were invented
- But traffic to edge nodes requires handling of direct end points communications (EAST-WEST)
- This is also crucial for mobile functional split



PON-based solutions

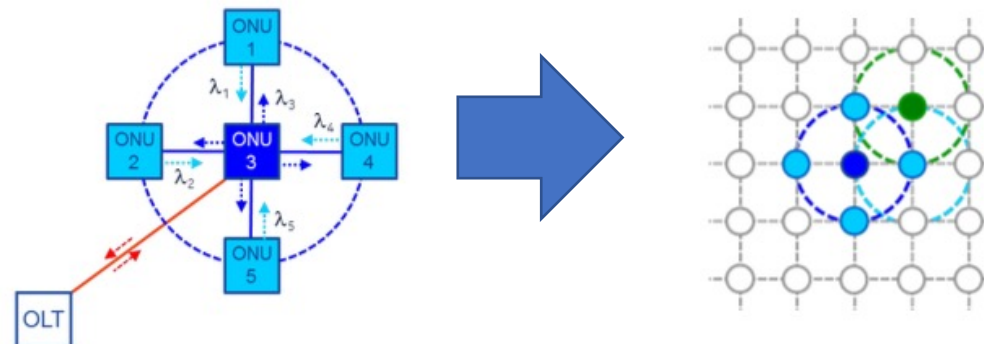
Using active networks, with Ethernet switches at every splitter not a preferred option... so

PON solutions:



Fully passive solution

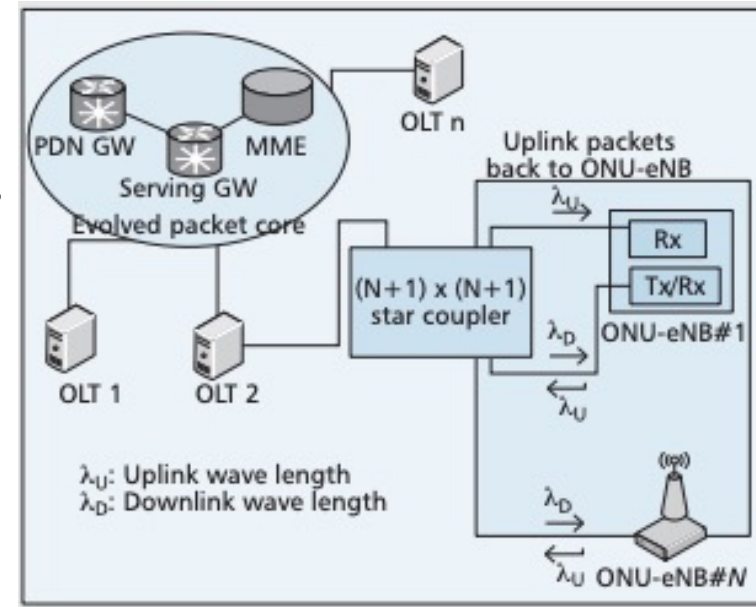
Th. Pfeiffer, "Converged heterogeneous optical metro-access networks," ECOC 2010, paper Tu.5.B.1



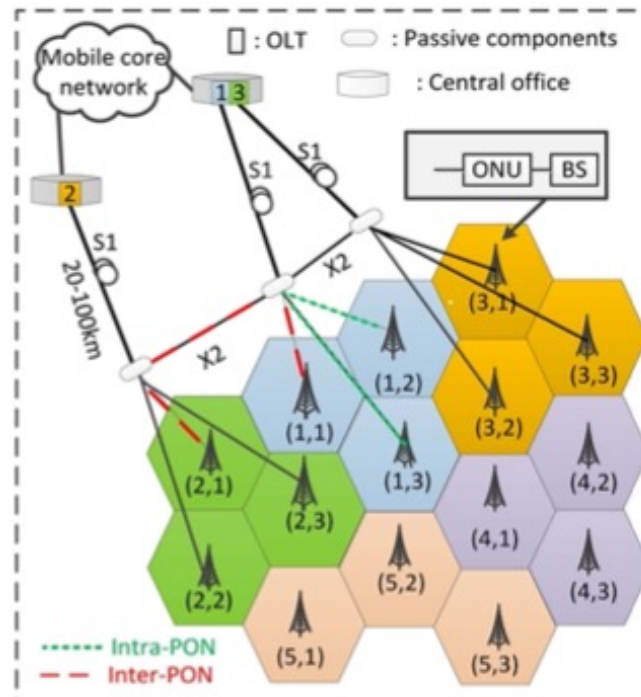
Less flexibility in direct links, more suitable for macro to small cell communications

PON-based solutions

- Use of passive star coupler
Focused on mobile base station connectivity.
Fully passive solution, but limited scalability



C. Ranaweera, E. Wong, C. Lim, and A. Nirmalathas, "Next generation optical-wireless converged network architectures," IEEE Network 26, 22–27 (2012).

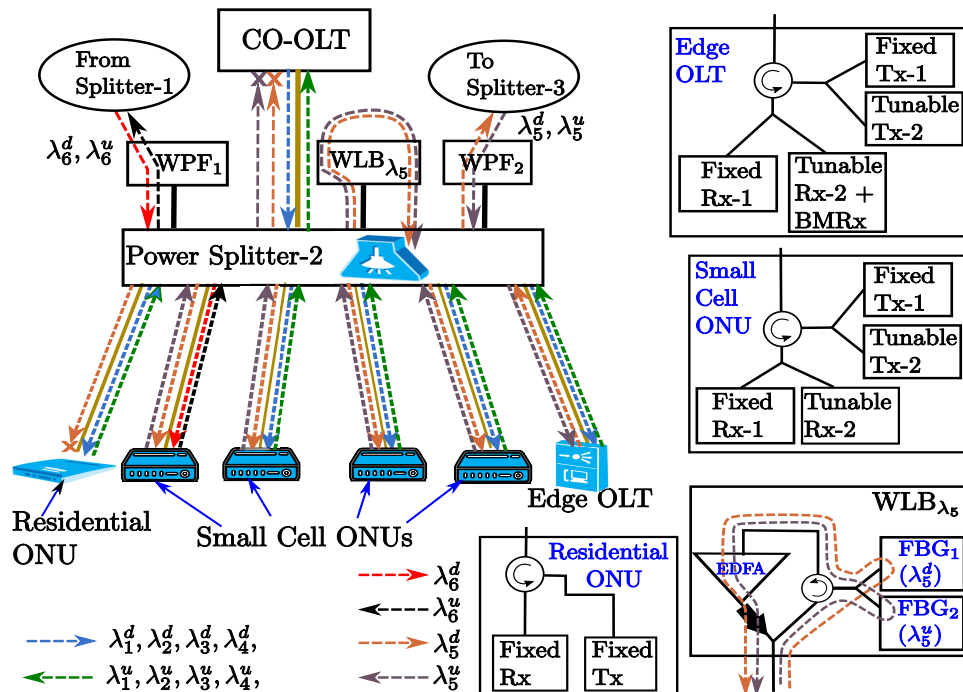


J. Li and J. Chen, "Passive optical network based mobile backhaul enabling ultra-low latency for communications among base stations," IEEE/OSA Journal of Optical Communications and Networking 9, 855– 863 (2017).

Passive solution: use of additional fibre to link splitters on same stage,
Difficult to reuse wavelengths, so some scalability issues.

Actively controlled components

- Fully passive components are great but limit scalability.
- Proposing use of actively controlled component (i.e., tunable optical reflectors) can help improve scalability and control over slices.



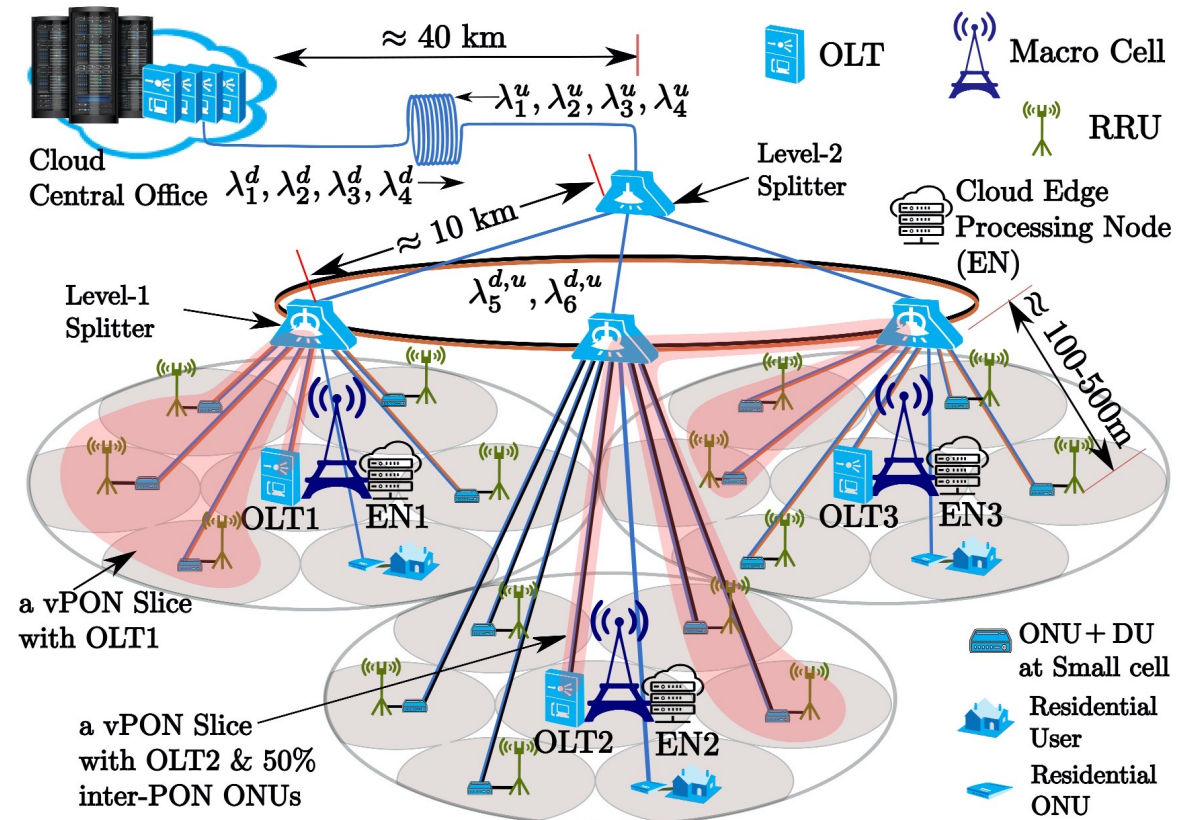
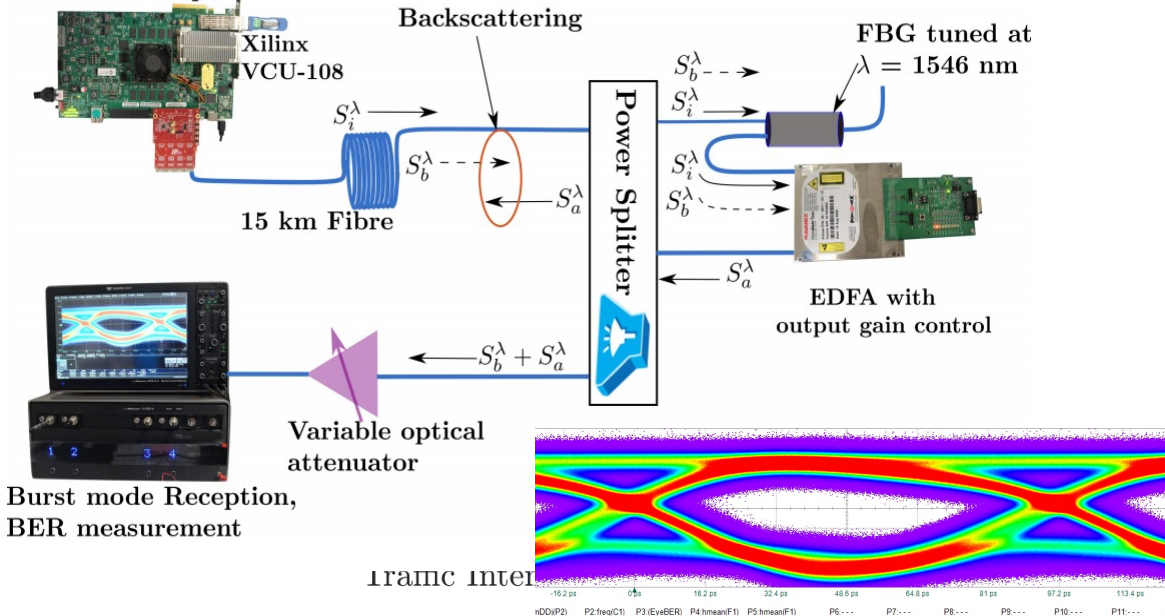
- Example use of Fibre Bragg Gratings
- Power loss going through splitter, but OK for last stage.
- Higher stage splitter might need amplifier integrated with FBG.

Other technologies could be investigated...
e.g., power/wavelength re-configurable splitters

Virtualisation aspects

- The core aspect is our virtualization technology (virtual DBA)
- Creation of dynamic slices with different group of end points.
- Enable the use of wavelength and time domains making it independent across services (as well as tenants)

ONU Generating
Burst mode traffic
at 10.3125 Gbps



Largely unaffected by signal reflections

Open Ireland: Ireland's Open Networking Testbed

➤ Testbed for research on end-to-end: wireless-optical-cloud based on **open interfaces** and **open source**

➤ **Investigate** end-to-end operation of OpenRAN, Cloud Central Office and Disaggregated optical systems.

- ORAN 5G Indoor and Outdoor
- Optical metro: 2,000 km fibre, SDN ROADMs, ESFAs, Transponder
- Access network (PON) virtualization and edge cloud

Network Orchestration

AI-driven automation ✓	Customisation ✓
Wireless/optical/cloud Convergence ✓	Open source/interface ✓

In support for new services

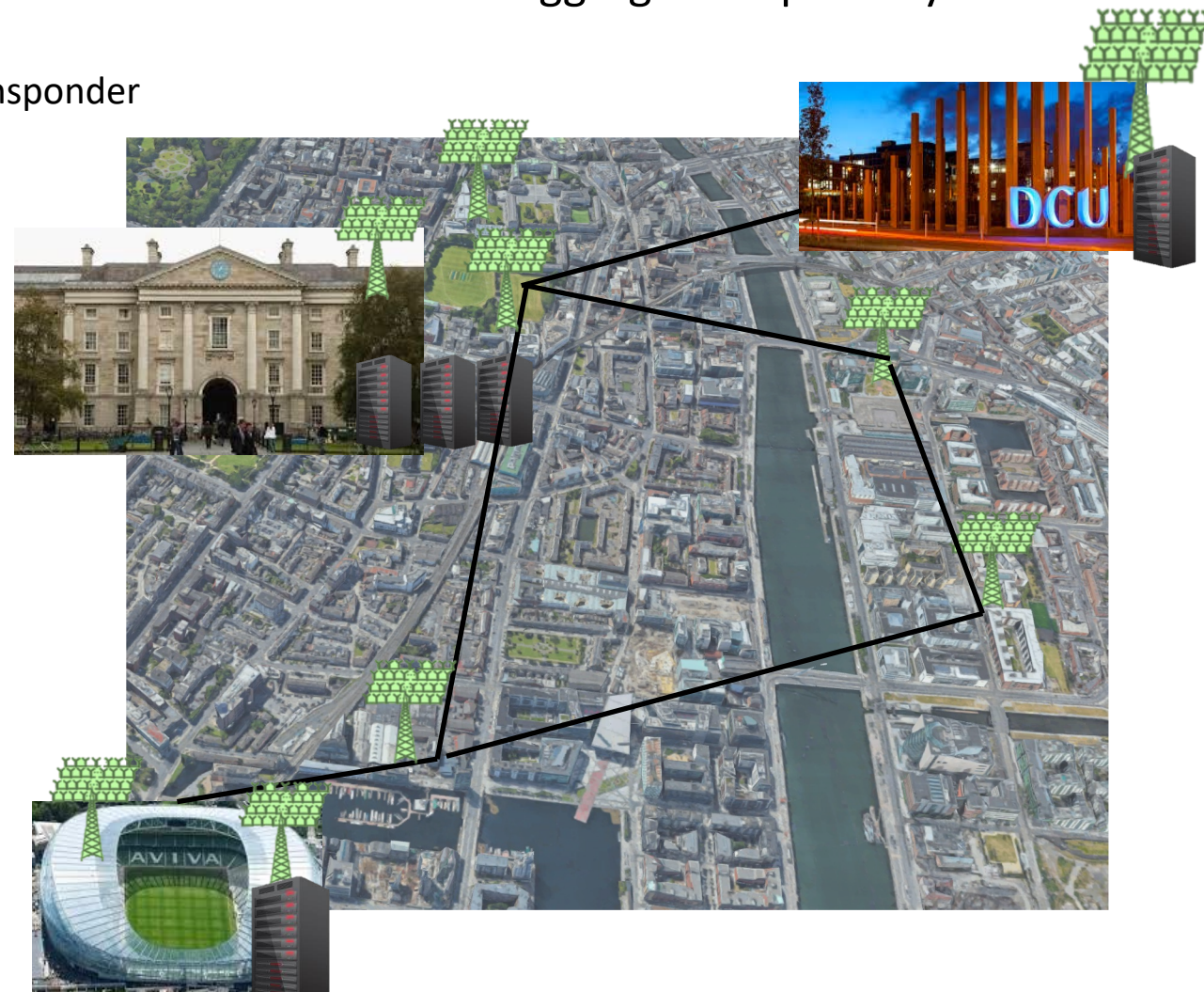
Extended Reality ✓	Connected vehicles ✓
Cloud Robotics ✓	eHealth ✓

New Technology

OpenRAN and radio frequency ✓
Disaggregated Optical networking, transmission and switching ✓
Edge cloud ✓

Infrastructure sharing

Many Services ✓
Many operators ✓
Smart contracts ✓



Conclusions

- Edge compute important not just for RAN implementation, but for general compute offload for lightweight devices...
...the ones we really hope to use in a near future
- Some interesting applications like object recognition and tracking require large computation and fast response time
- AR/VR as a service could be a compelling idea also for home usage (...avoid turning your home into a small DC)
- Use of edge compute is well established in research literature and industry roadmap..
- We address a still widely open challenge of providing low-cost mesh connectivity deep in the network access

