A World Leading SFI Research Centre

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Coláiste na Tríonóide, Baile Átha Clia
The University of Dublin

CONNECT
Centre for Future Networks

Open Networking to enable end-to-end network research across wireless, optical and cloud domains

Prof. Marco Ruffini
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CONNECT and IPIC research centres

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Co-funded by the Irish Government and the European Union

European Union
European Regional Development Fund

Science Foundation Ireland sfi For what's next

IPIC
BRINGING PHOTONICS TO LIFE

Marco Ruffini, Ph.D. (2008)

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https://marcoruffini.com/ Full CV available HERE

- ✓ Associate Professor and Fellow of TCD
- ✓ PI in CONNECT and IPIC; Head of the Optical Network Architecture lab
- ✓ 140 International publications, 10s patents
- ✓ €7M raised in competitive funding

- ➢ Access Network Virtualisation
  - ➢ The Virtual DBA and Full virtual PON prototype
  - ➢ Mobile-optical-cloud convergence
  - ➢ Use of blockchain for access network sharing
  - ➢ Mesh architectures for edge cloud
- ➢ Disaggregated optical networks:
  - ➢ Mininet-Optical: network emulation for optical disaggregation
  - ➢ Machine learning for Quality of Transmission Estimation
  - ➢ Open Networking testbed for disaggregated access-metro
- ➢ Fixed-Mobile Convergence:
  - ➢ Variable Rate Fronthaul scheme for PON transport
  - ➢ SDN based integrated LTE-PON control system

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The Research group

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5 more researchers joining soon: 2PD + 3 PhDs

Blockchain in telecomms

Mininet-Optical

ML for QoT estimation

DBA virtualization for multi-tenancy

Open Networking testbed

Fixed-mobile convergence

Hardware programmability with P4

Dynamic spectrum for satellites

Multi-Access Edge Computing

Mesh PON access

SDN for optical components and disaggregated testbeds

Free space optics backhaul

Rural LR-PON deployments

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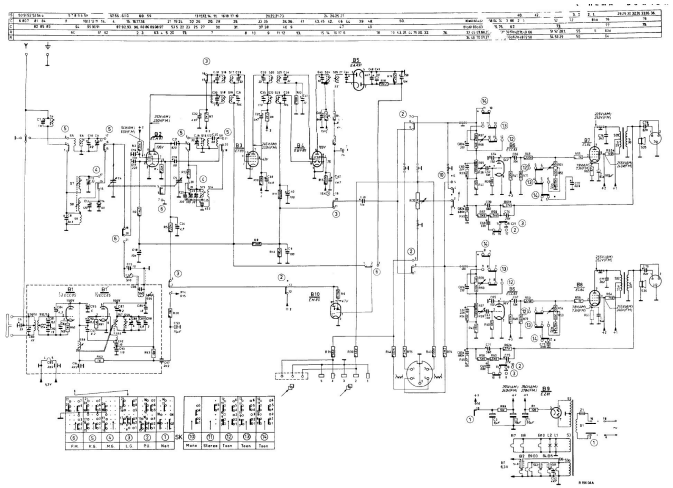
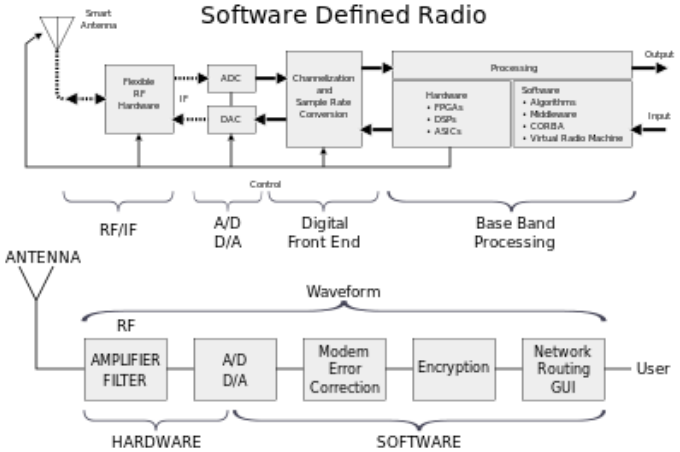
The Open Movement

- Software Defined Radio introduced in 1992 by Mitola in IEEE journal

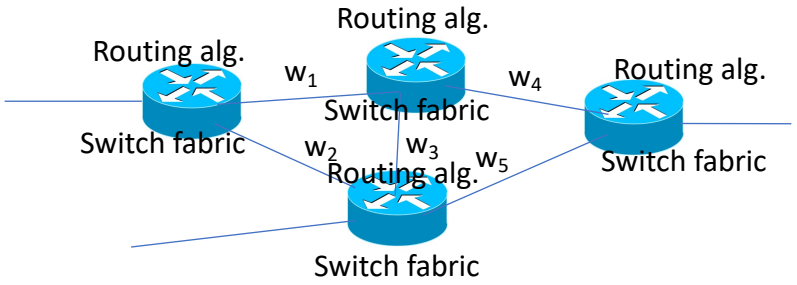
1. Moving from hardware to software is the first step for opening up a system
   - Software can be copied, downloaded, etc. and can be worked on by anyone.

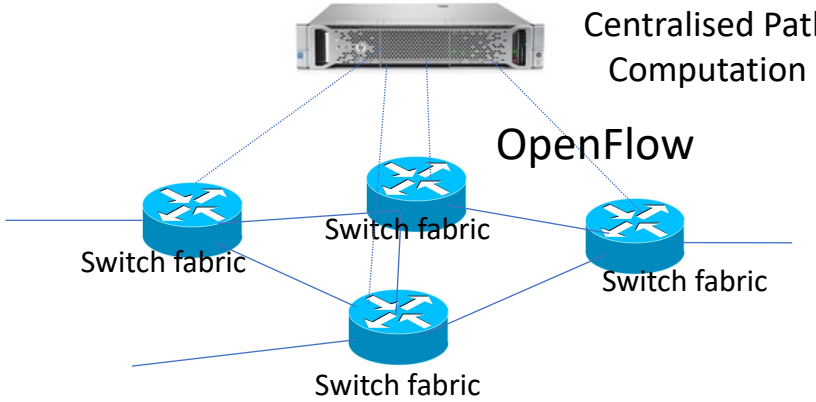




2. The second innovation in 2008 was the separation of control and data planes.

➔ It means providing an open interface (OpenFlow / SDN) so that the hardware and software could communicate across a distance





Opening the central office

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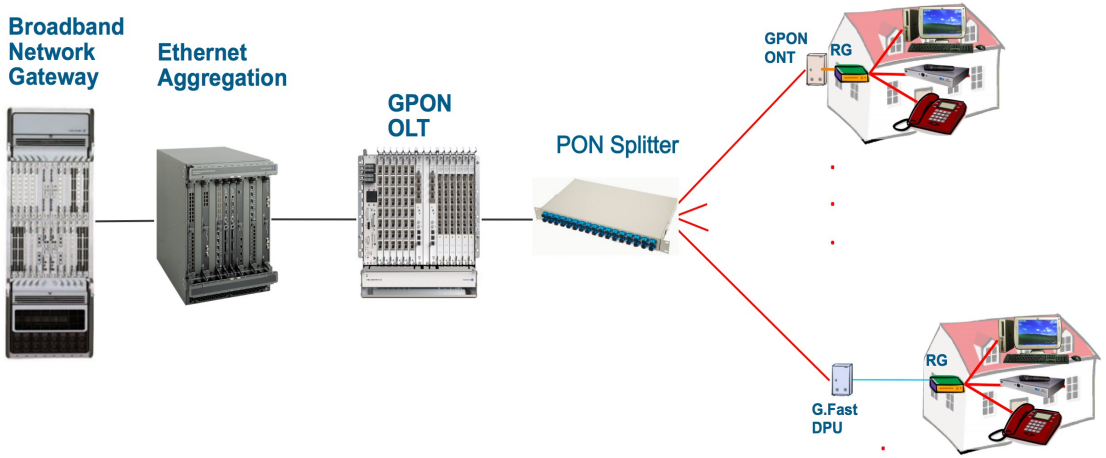
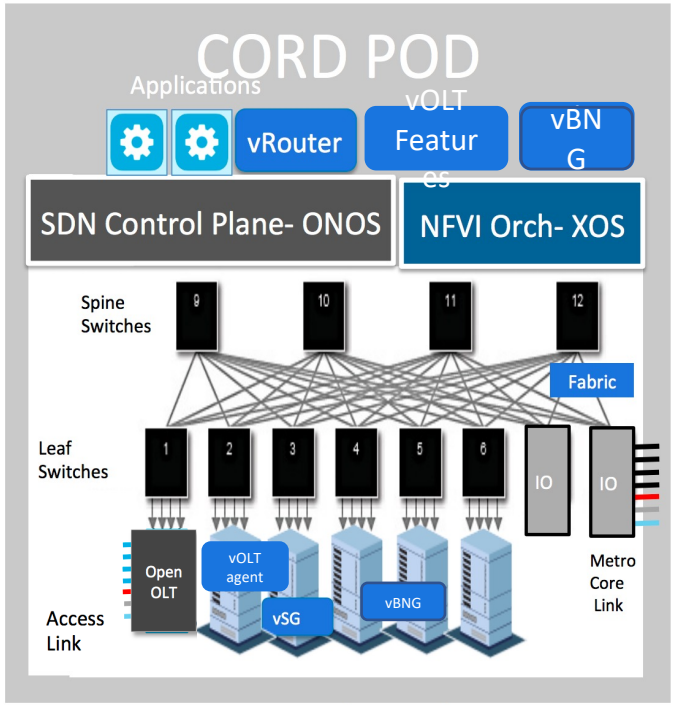
- Over the past 10 years the concept has evolved from academic research and individual devices, to telecoms network scale.
- The central office is being “Softwarised” or “Cloudified”. Started in 2015 with the Central Office Rearchitected as a Data Centre (CORD), from Stanford and AT&T, then turned into the Open Networking Foundation (ONF).





Commodity Hardware

This has now evolved into the SDN-Enabled Broadband (SEBA)

Also, other entities have defined Cloud-CO (BBF), Open Network automation Platform (ONAP),…

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Opening the optical layer

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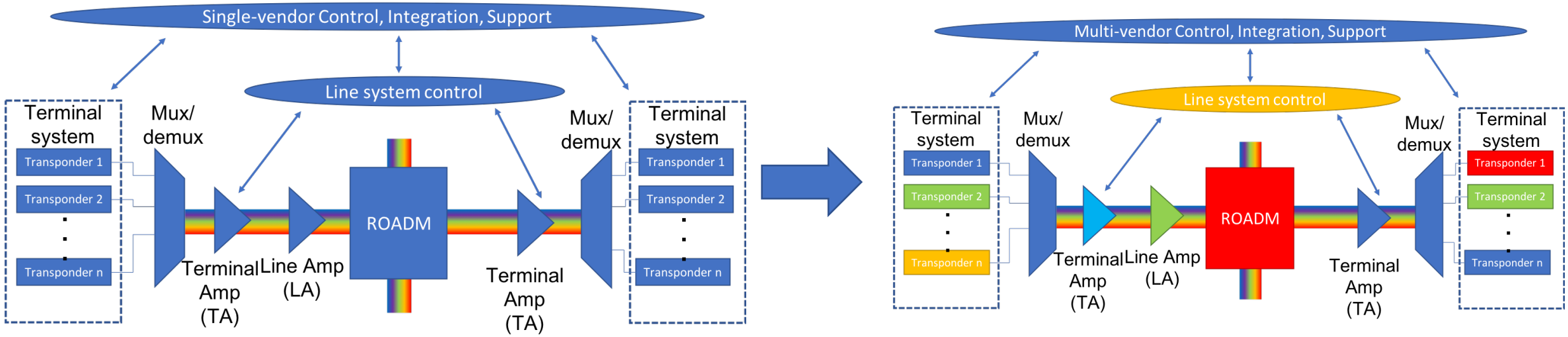
- This is a difficult one!
- Optical transmission is analogue, meaning that different devices have different behavior (unlike digital)
- Nonetheless now there are SDN-controlled ”whitebox” devices, like ROADMs, amplifiers and transponders..



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Opening the base station

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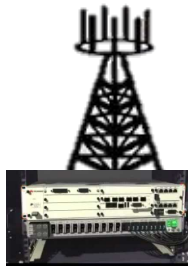
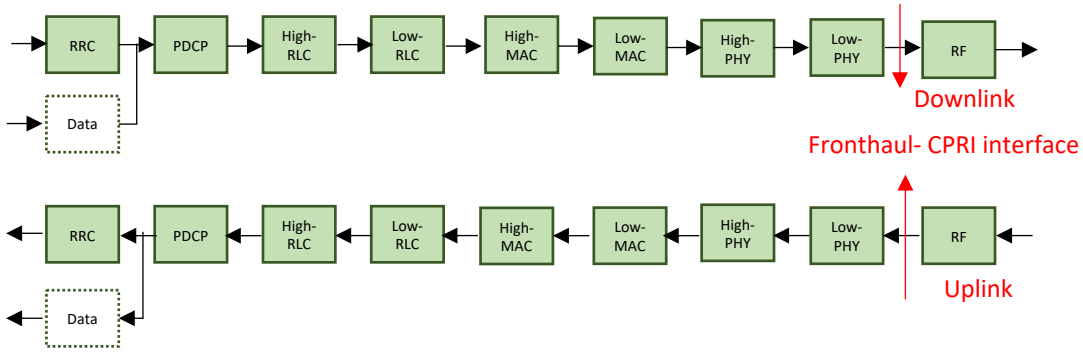
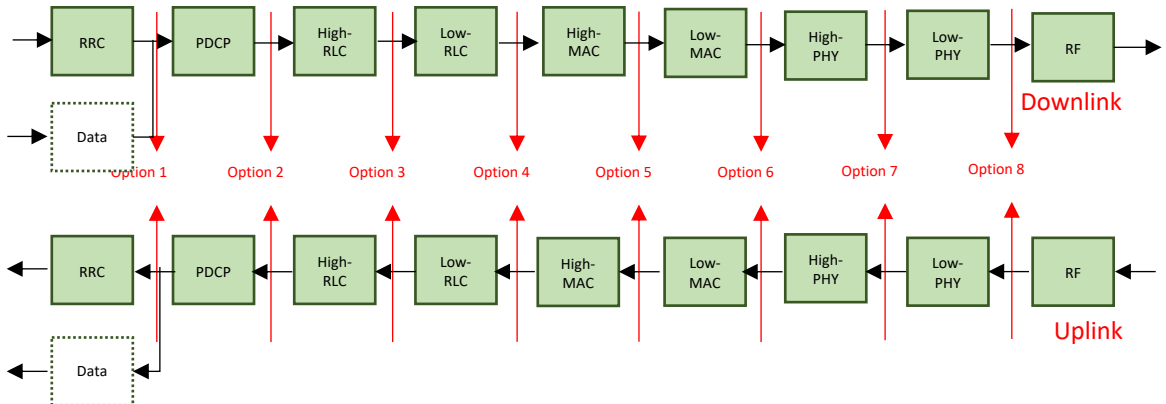
- For over 10 years we have been able to do this: run a 4G base station from a laptop



Remote unit (RU)



- Over that past 5 years industry fora have come together to define other split points for separating Remote Unit – RU (hardware) from the rest (Distributed Unit and Centralised Unit). Alternatives to CPRI.



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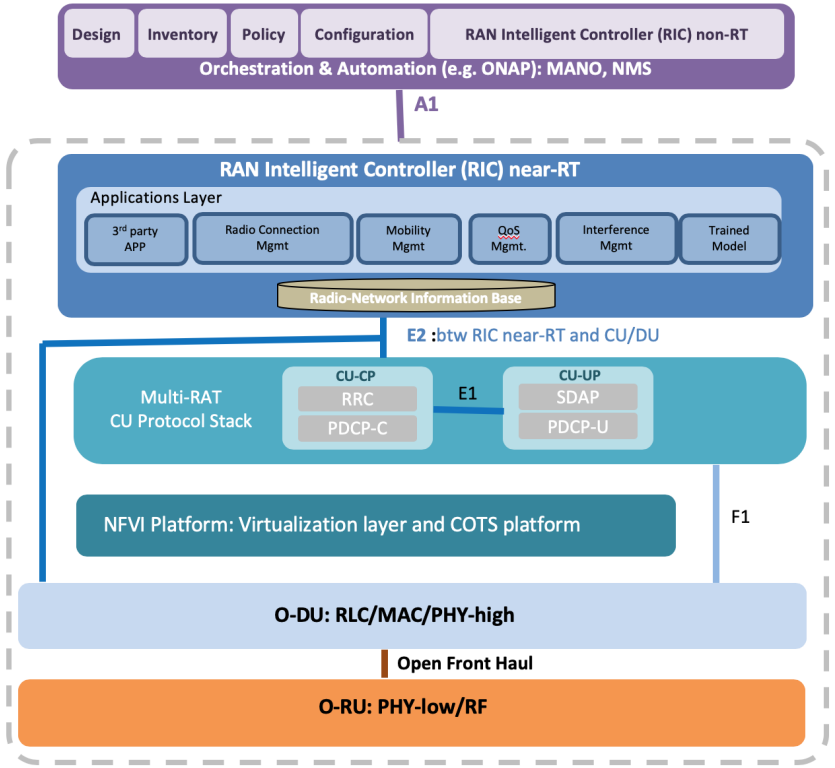
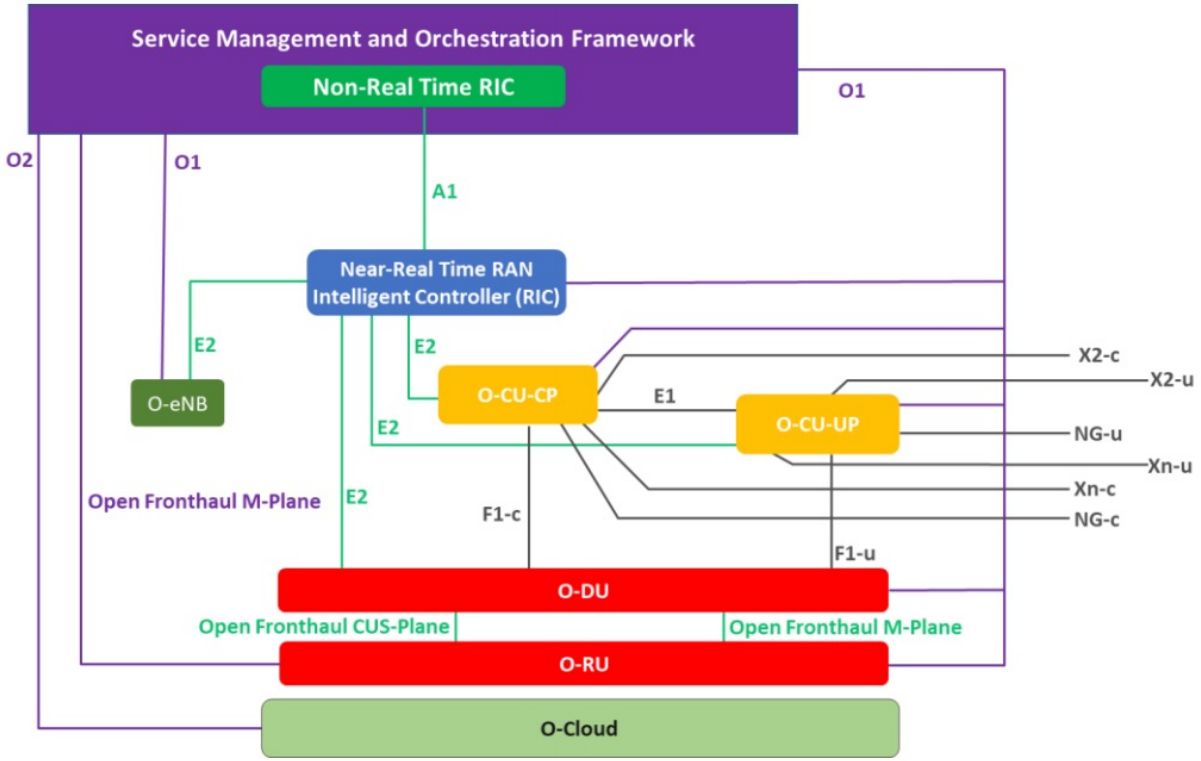
Opening the Radio Access Network – O-RAN

- Next step is to bring this concept to proper commercialization (actually replacing current large vendor base stations)
- Define one one specific split (called 7.2) and start defining interfaces so that vendors can start producing the different parts





Pros and Cons

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- First and foremost: AVOID VENDOR LOCK-IN
  - Ability to add new features from other vendors
  - Get the best from each vendor

- Create a more competitive environment: lower cost, more research!
  - Enable Universities and SMEs to take part to the research INDEPENDENTLY
  - Create the environment for new startups to get to market

- First and foremost: who is going to put the system back together for the operator?
  - This is what vendors have done in the past, but if the system is made up of bits and pieces, who will deliver the working system to the vendor?
  - Risk to get back to a few large companies doing the aggregation…
  - …but maybe that's the way to go, think of Dell, etc.

- It surely gives us the possibility to do very interesting research on Real Life systems

What needs to happen for OPEN RAN to achieve success from a research perspective?

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- From a research perspective disaggregation is the best that has ever happened to us! … We can now work on real systems!
  - With OpenFlow we are able to do things that before only large companies could do
  - With SDR we could run a base station from a laptop
  - With CORD we can trial a central office from one server

- Suitable for use of Machine Learning, which needs real data
- We had successful spinouts (Software Radio Systems – SRS), and other commercialisation activities, all thanks to the Open Movement
- <u>We can bring ideas to commercialisation in the blink of an eye</u>

What are key challenges to OPEN RAN and the "OPEN" movement from a research perspective?

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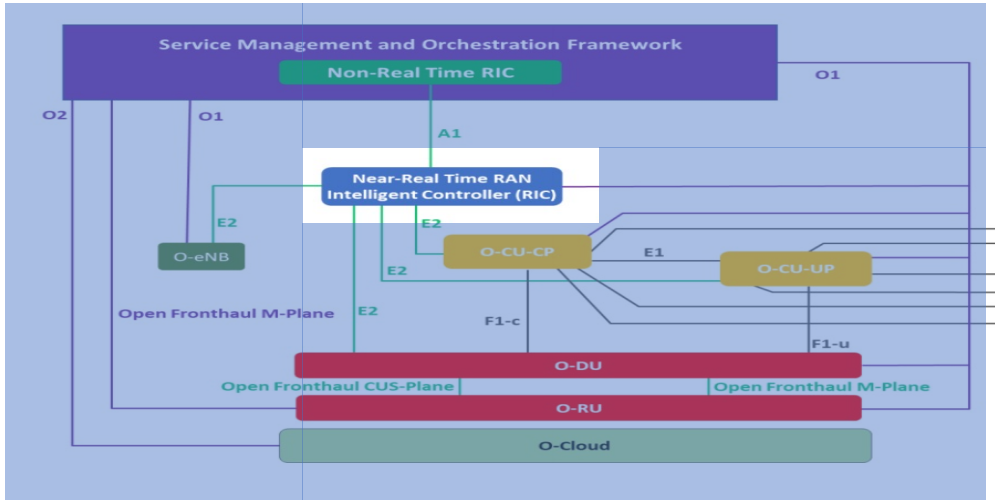
- Entry barrier: if I'm interested in developing one element (say the Radio Intelligent Controller - RIC), I need the full system for performance testing,…



- <u>Open source implementation of the standard components is important</u>!
  Open Air Interface, SRS, Magma (Facebook),...

- OpenSource is a means for faster products development.. We want to focus on real value (network automation, intelligent control, etc..) and spin off!

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Why is Software key in OPEN networks? is it changing the relationship between industry and academia?

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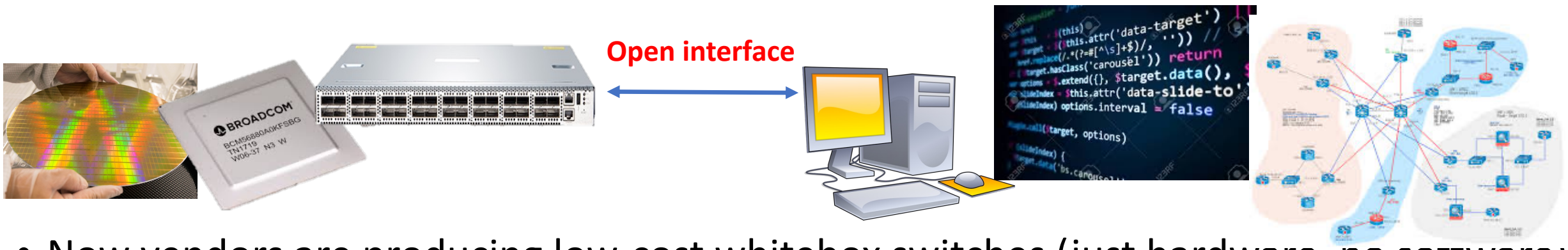
- Software has been a key aspect in network devices long before moving into open systems..
  - A router is made of dumb ultra-fast silicon data plane (few vendors) and massive amount of software (intelligence, flexibility, etc)
- Open networking has created a physical separation between the silicon and the software. **And it has standardised and opened the interface between the two**.



- Now vendors are producing low-cost whitebox switches (just hardware, no software): a 3.2 Tb/s switch costs less than €7k! (the same as an entry level iMAC Pro)
- … so now we can design control plane software like any other company

… and test it quickly on a real network: brings academy and industry much closer

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How is research on OpenRAN and Open Networking progressing in Ireland?

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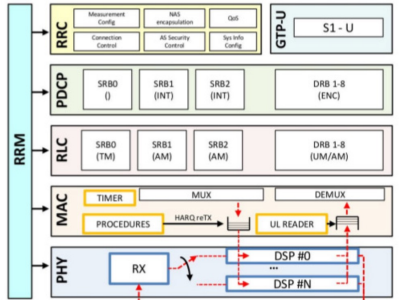
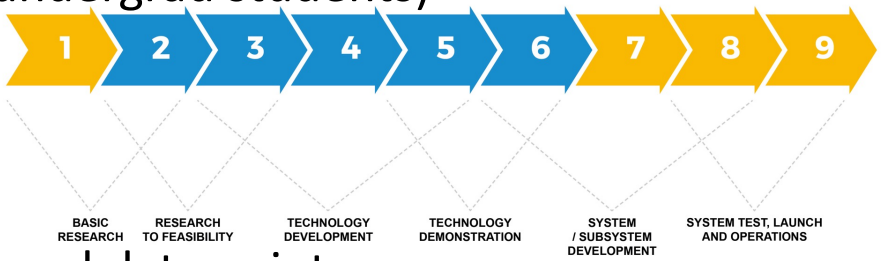
- The CONNECT research centre has been a pioneer in Ireland.
  - SDR work from Linda Doyle (year 2000), then continued by Luiz Da Silva.
  - I have pioneered the virtualisaton of the Passive Optical Network (now standardised at BroadBand Forum)
  - TSSG's world leading work on SDN
- Irish SMEs (CONNECT's partners) heavily involved:

aspire Perfecting Networks

SRS SOFTWARE RADIO SYSTEMS



- **<u>Our position is KEY</u>**, as we can provide a <u>neutral environment</u> for research and experimentation in real networks.
  - We work with industry on Targeted Projects
  - We do commercialisation projects and spin offs – in addition to national an EU funded research
  - **We educate!** (training PhD students, postdocs, as well as undergrad students)
- Testbeds are a key enabler
  - Testbed validation increases the value of our research
  - We can move faster up the TRL scale
  - AI and machine learnings are based on the use of real data points



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Open Ireland: Ireland's Open Networking Testbed

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- 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.
- Investigate intelligent control plane, technology and protocols and to enable 100X scalability:
  - Capacity, Latency, Availability, Energy, Automation…

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

Infrastructure sharing
Many Services ✓
Many operators ✓
Smart contracts ✓

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

In support for new services	
Extended Reality ✓	Connected vehicles ✓
Cloud Robotics ✓	eHealth ✓

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Physical infrastructure around the city

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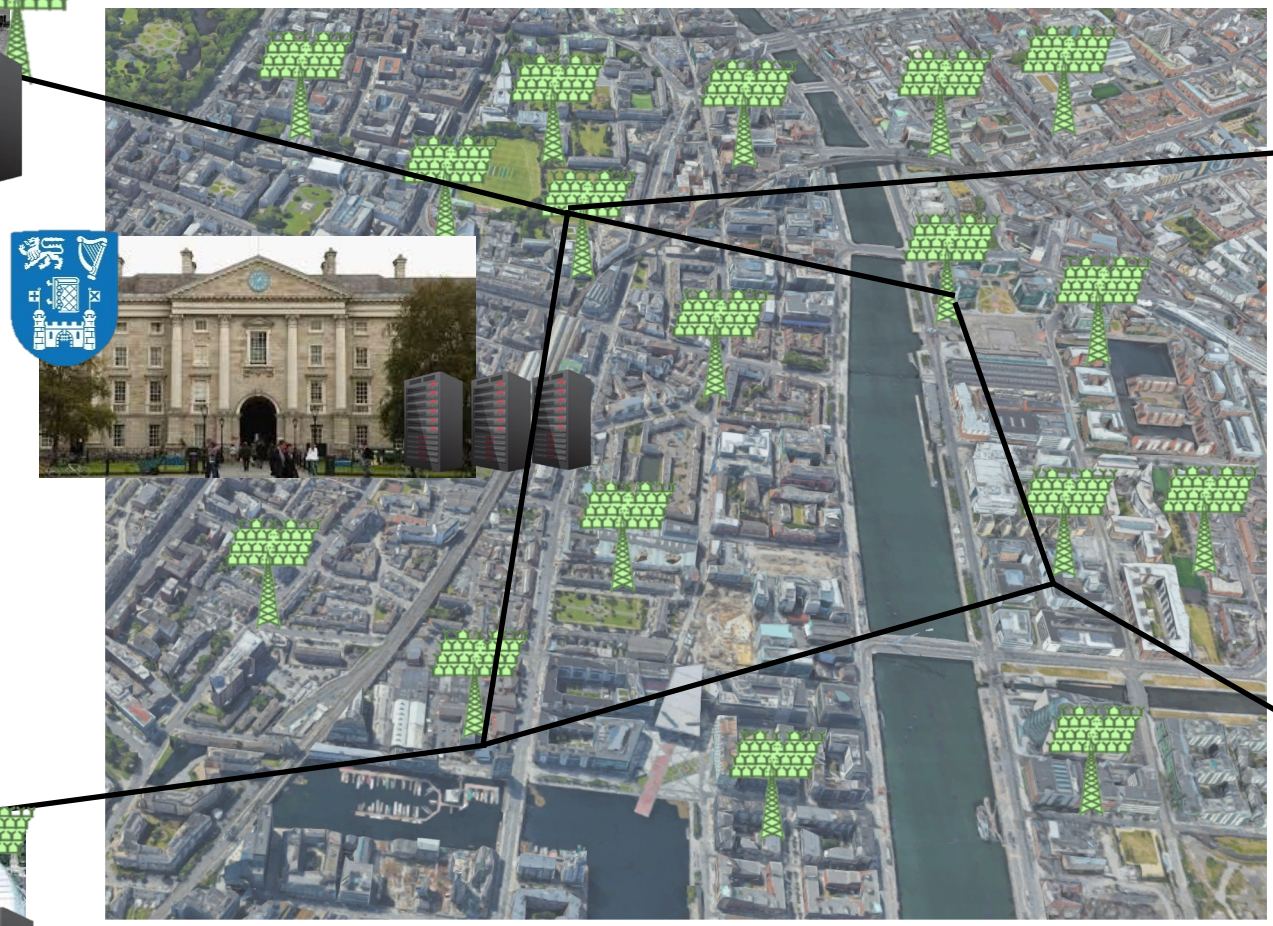
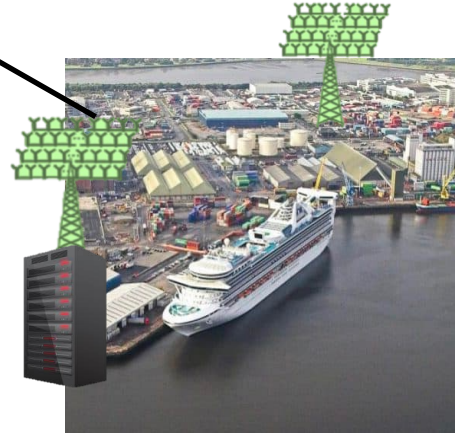


Radio and Optical Communications Laboratory

- Indoor-outdoor wireless
- Optical metro: 2000 km of fibre transmission
- Network virtualization and edge cloud



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Just some example of research projects…

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- We are active in several research areas:
  - Access network virtualisation
  - Intelligent (AI-based) network control for both wireless and optical systems
  - Mesh access networks for supporting edge cloud and cloud-RAN
  - Telemetry for monitoring quality of service and meet Service Level Agreements
  - Use of distributed ledger technology to implement smart contracts
  - Algorithms for migration of micro-services in open systems
  - … and much more