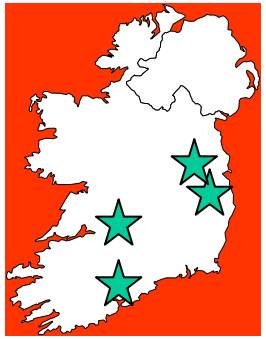
CTVR & Future Internet Testbeds

Donal O'Mahony & Stephen Farrell

Centre for Telecommunications Value-Chain Research (CTVR)

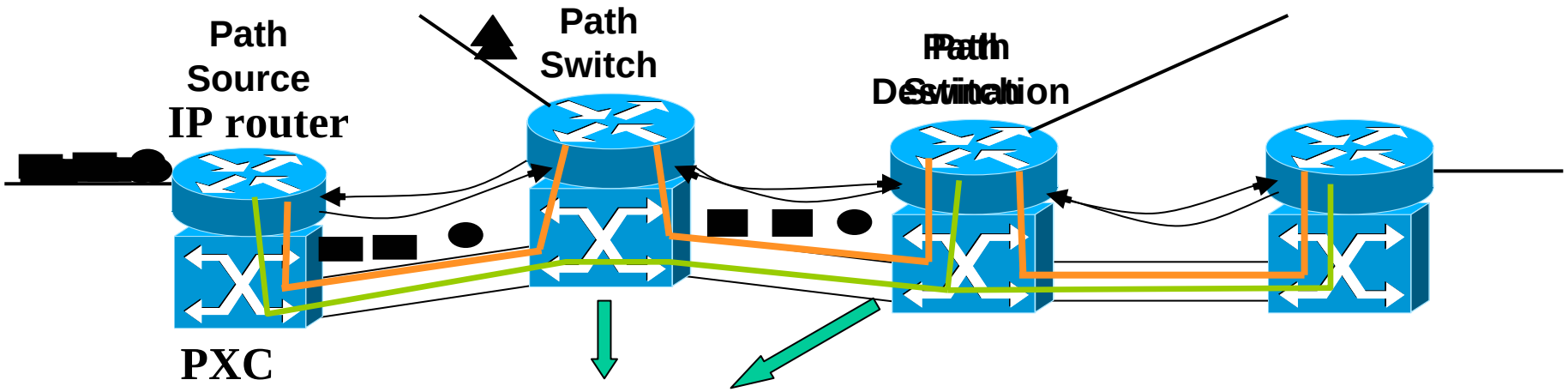


- Research Centre based in Ireland focussing on research on those problems in telecommunications with maximum impact on future value-chains
- Approximately 100 researchers
- Topics of interest include: cognitive radio, optical networking, network architectures, DTN, security
- Funded by Science Foundation Ireland
- €20m ($US28m) over 5-years with option to renew
- Industry-Guided partnering with: Bell Labs Ireland (Alcatel-Lucent), Xilinx, EADS, TDK …

CTVR Optical Control-Plane Research

- 30 second intro to Optical IP Switching Idea
- How we tested it
- How we might do it with GENI

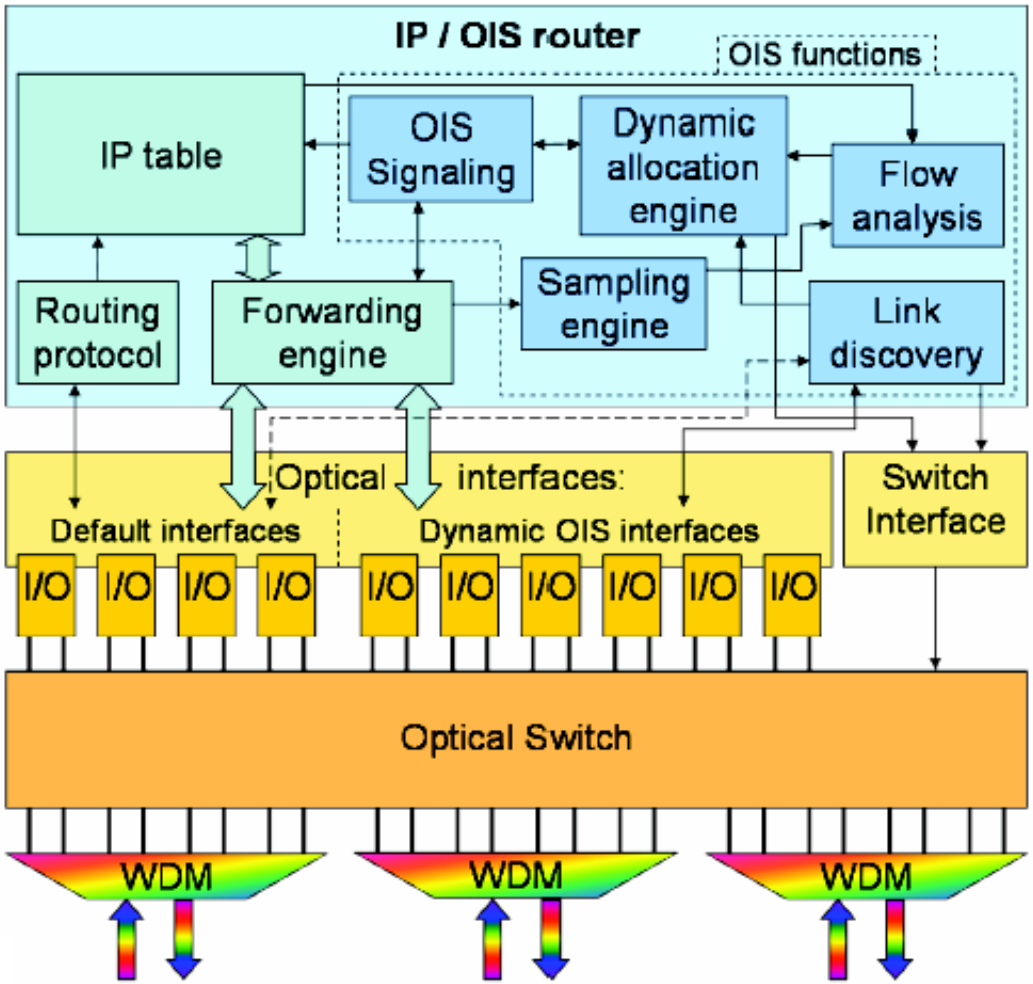
Optical IP Switching (OIS)



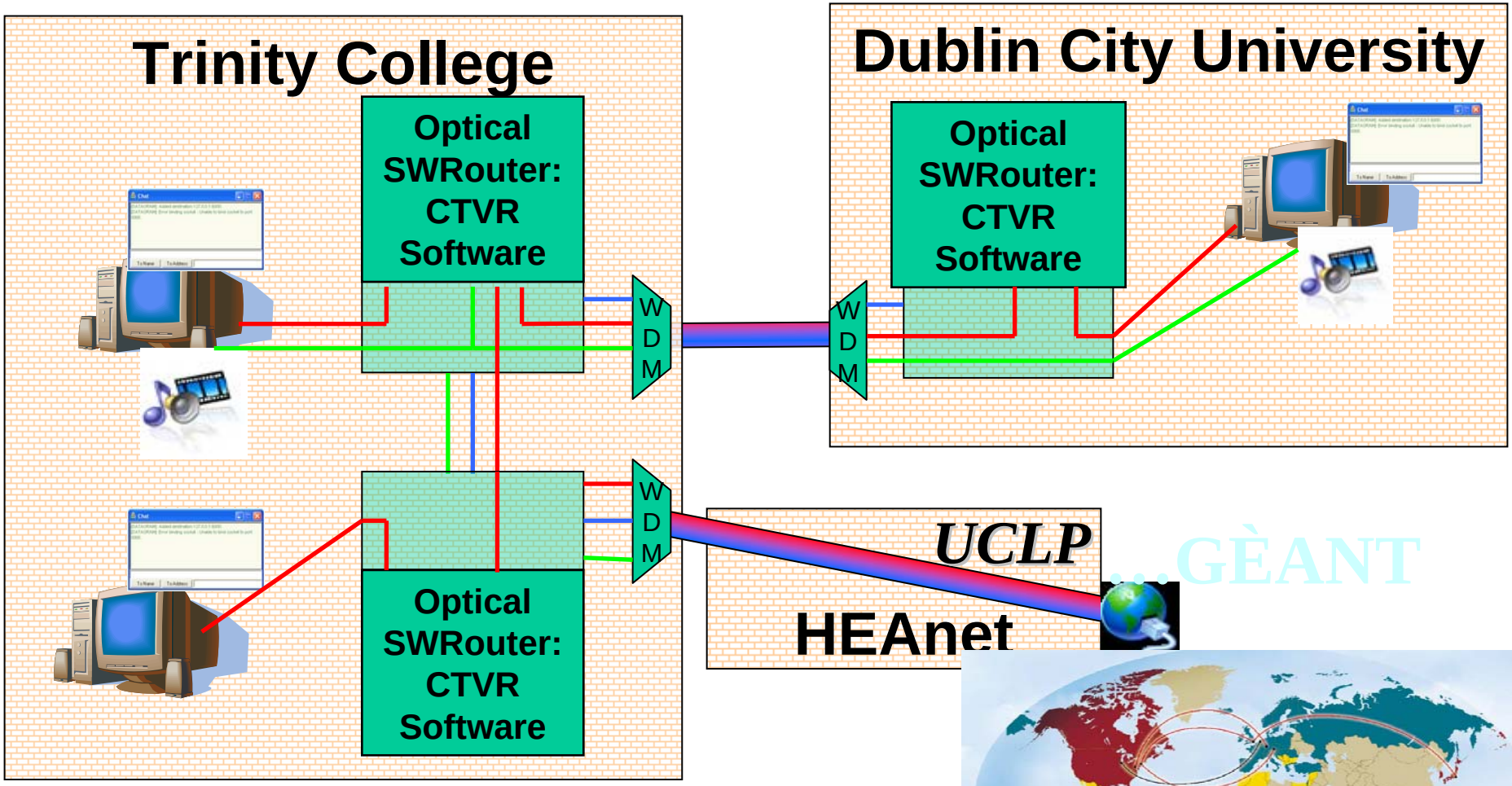
1. Flow detection
2. Neighbour signaling
3. Optical cut-through path creation

Path Extension Process

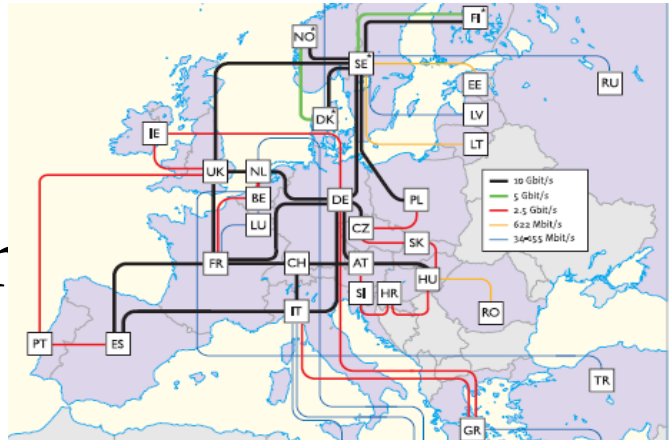
Testing… The Node Architecture



Testing… The All-Optical Test Network



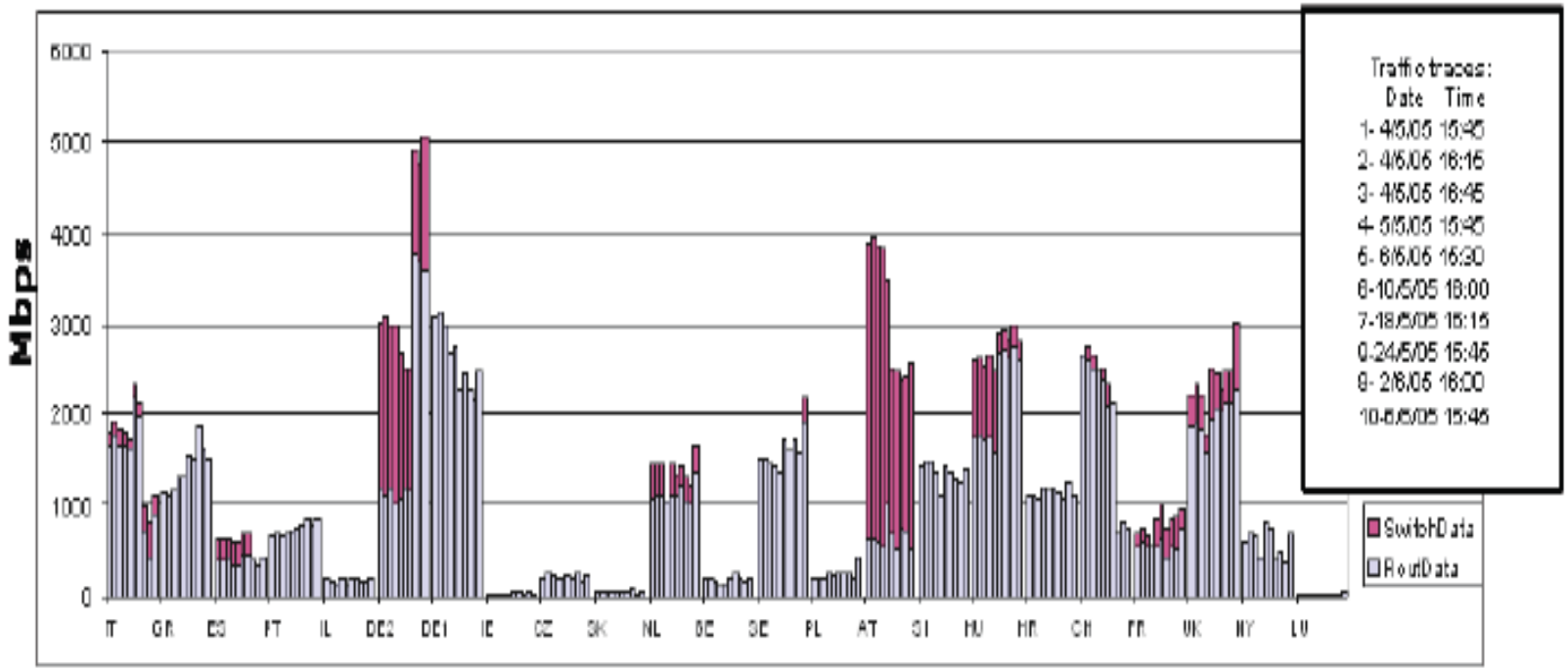
Data for the Analysis



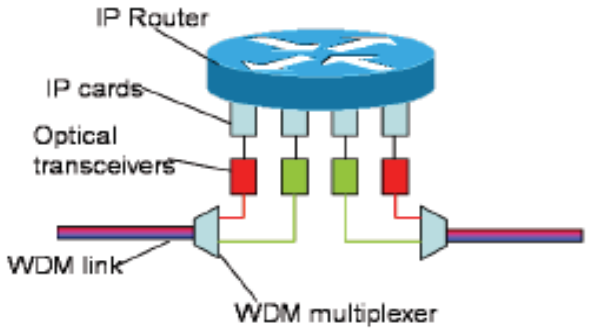
- Needed to see how the network would perform under load
- Used C-BGP from UC Louvain
- Were able to build a simulation of an OIS network and drive it with historic GEANT traffic traces

Example Results – Switching/Routing Behaviour

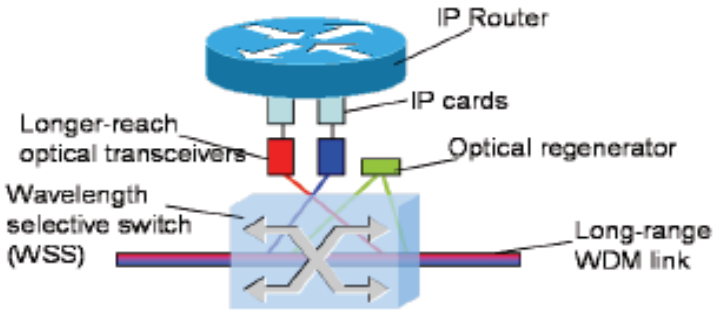
switched



Example Results – Cost Analysis



A. Node model for point-to-point routing architecture



B. Node model for Optical IP Switching architecture

Costs	units
IP card (10G)	120
IP router (per 160G traffic)	50
Transceiver 800km range	1.3
Transceiver 2500km range	2.2
Signal regenerator	2.7
WDM system 40λ	4.5
WDM system 80λ	6.7
link cost 800 km reach	50
link cost 2500 km reach	70

WSS costs	units
WSS 4-ports 40λ	3.8
WSS 9-ports 40λ	4.8
WSS 4-ports 80λ	4.2
WSS 9-ports 80λ	5.2

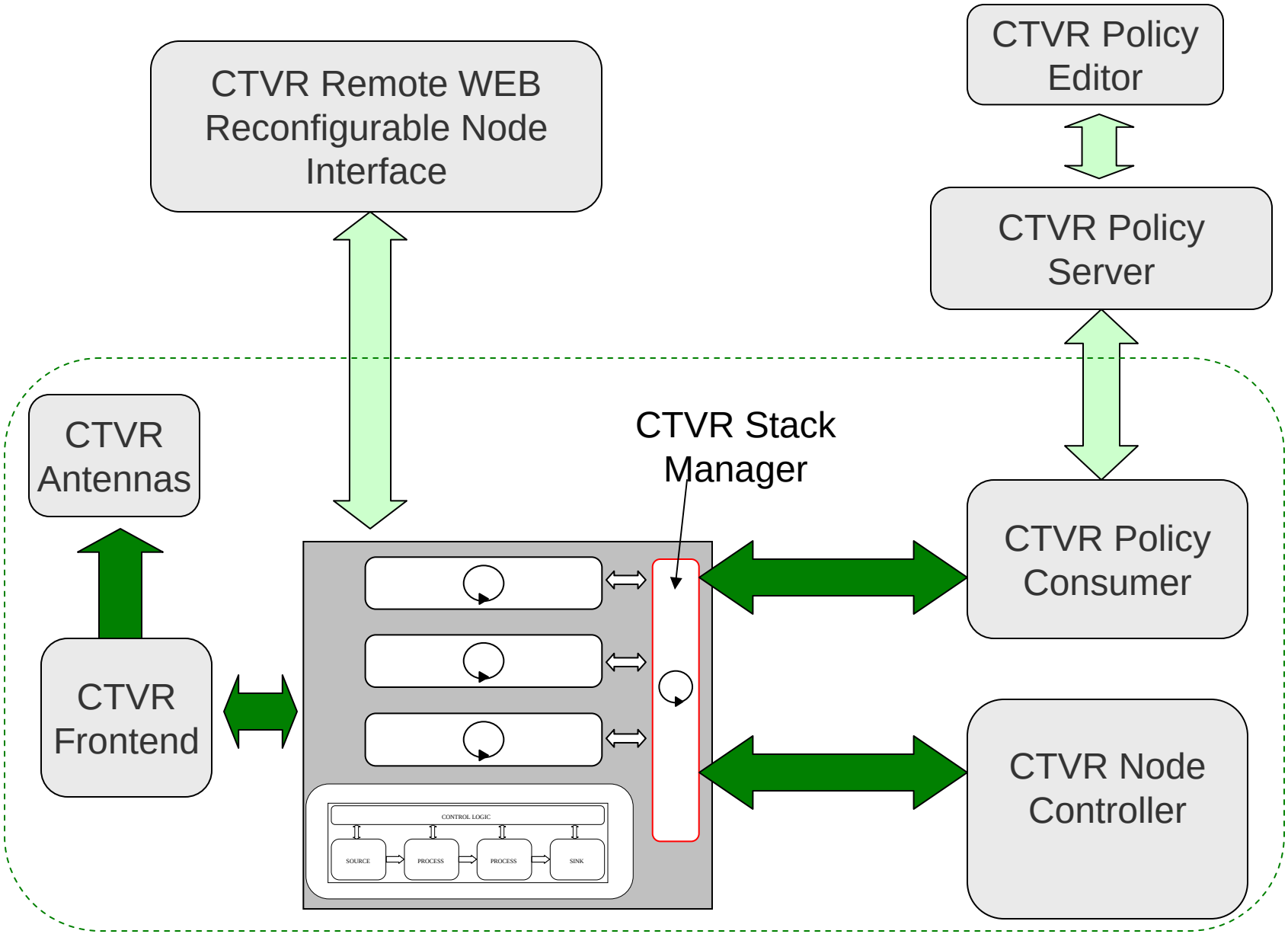
Fit with GENI phase 1 and beyond

- Could contribute resources to the global infrastructure: (3 x all-optical switches), local routers, host geni-ized routers, Planetlab site
- Provide a trans-atlantic link with 1GEs, 10GEs…lambdas
- Could use the GENI infrastructure to prototype a global-scale OIS network
- Contribute experiences with traffic generation, costing etc
- Act as Link with European Initiatives e.g FEDERICA, PHOSPHORUS…

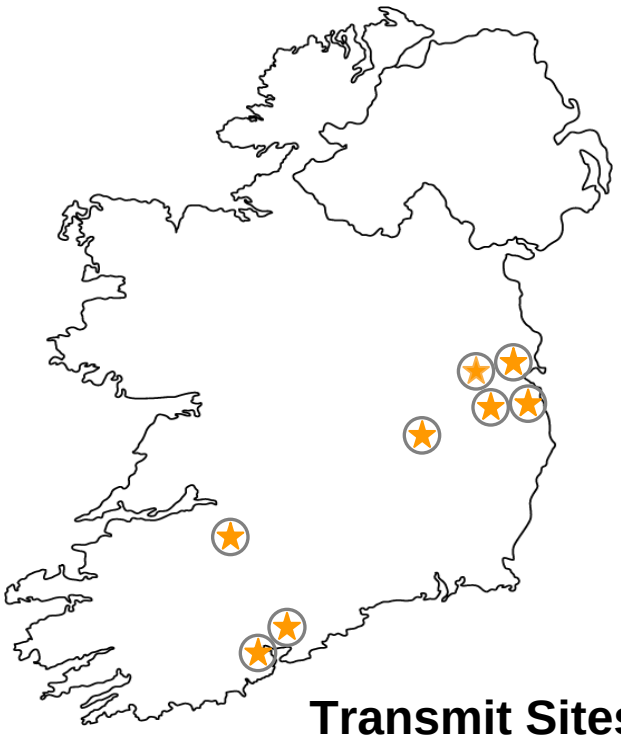
Cognitive Radio Activity

- Major focus area for CTVR is re-configurable radio
  - 10-years of development effort gone in to IRIS Software Radio System
  - Prototype developed of Wide-band front-end
  - Suite of Wide-band and reconfigurable antenna designs
  - Extensive activity in policy side of Dynamic Spectrum Management

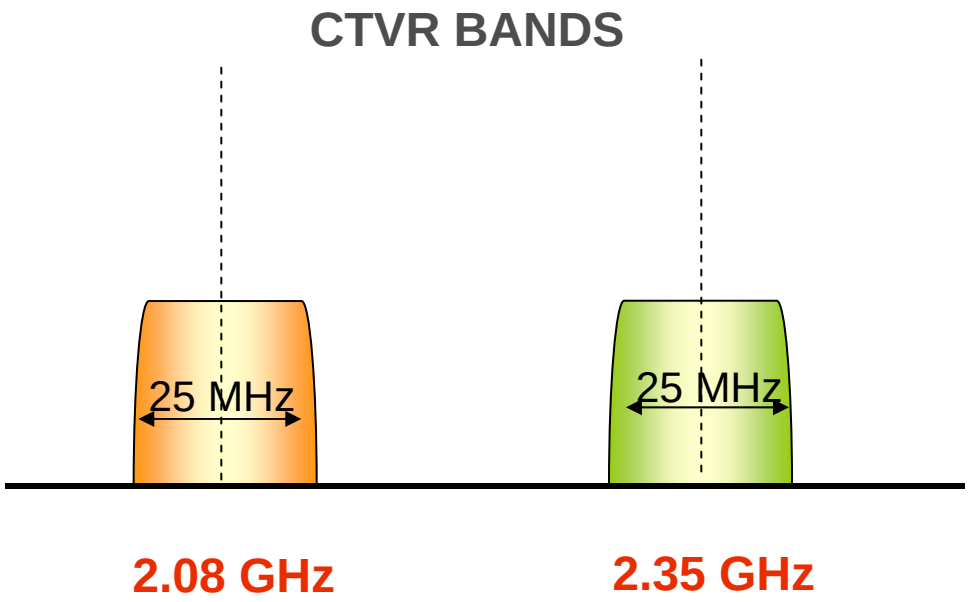
  - CTVR in Trinity, Wireless@VirginiaTech, the KUAR (Kansas University Agile Radio) team in Kansas, WINLAB@Rutgers and University of Colorado at Boulder are all working towards the creation of a large scale collaborative testbed.


CTVR Remote WEB Reconfigurable Node Interface
CTVR Policy Editor
CTVR Policy Server
CTVR Antennas
CTVR Stack Manager
CTVR Policy Consumer
CTVR Frontend
CTVR Node Controller
CONTROL LOGIC
SOURCE
PROCESS
PROCESS
SINK

C T V R t e s t b e d



Transmit Sites

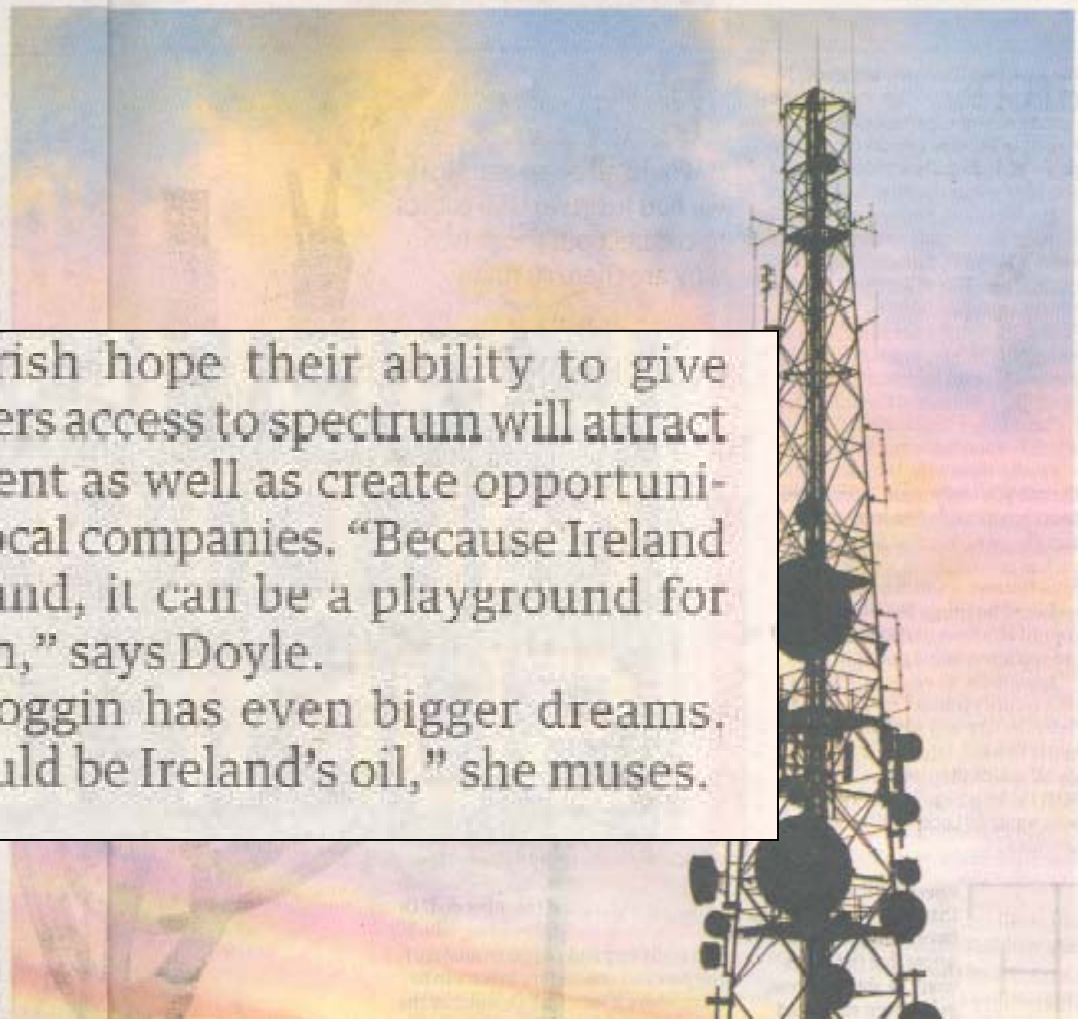


note: ComReg test license scheme

Overcrowded airwaves mean it's time to hop ahead

An increasing number of technologies rely on radio spectrum. Before it runs out, an Irish research group suggests we get used to sharing what we have left

By Karlin Lillington



Like oil, radio
world's dwind
would five mo
that infamous
the UK in 2000
a rarity?

Tightly cont
country, spectr
television broa
networks, mic
less networks,
satellites, cur
computer key
openers. And,
they're not bui

The explosi
and mobile d
greater strain
resource – so r
US-based Tec
report (http://t
"There are fe
resources than our radio spectrum. An increasingly essential platform for how we work, live, play and learn, radio spectrum may be the most critical infrastructure element of 21st century economies."

The council's idea of a solution to scarcity in the US is for the government there to give up some government-held

> The Irish hope their ability to give researchers access to spectrum will attract investment as well as create opportunities for local companies. "Because Ireland is an island, it can be a playground for spectrum," says Doyle.
>
> But Goggin has even bigger dreams. "This could be Ireland's oil," she muses.

had to use computer simulations.

Doyle says there isn't another regulator in the world that has been willing (or able) to grant spectrum for this kind of use. When, at a recent conference, she mentioned the grant to Michael Gallagher, the assistant secretary for communications and information of the US National Telecommunications and Information Administration, "he nearly fell off his chair," she says.

Isolde Goggin, the chair of ComReg, says it was able to offer the spectrum under its "test and trial" research and development programme because Ireland "is in a fairly fortunate position": a low population density means there is a lot of uncongested spectrum, and being an island on the western edge of Europe means the spectrum is cleanly isolated from neighbouring countries and the experiments are unlikely to cause interference. And it's not a Nato member, so the military won't complain.

New approach

For the same reason, Ireland has more spectrum available than countries with a large military. Goggin says that ComReg made the decision "to turn spectrum allocation around from a restrictive approach, to saying if we can do it, we will".

Doyle says spectrum-hopping would require a complete rethink of how commercial-use spectrum is allocated and paid for. Rather than a licensing system that lets operators control a fiefdom of spectrum – the current model, which the Tech CEO Council would like to see expanded – spectrum-hopping would be more like a frequency timeshare. One aspect of the research will be to consider

Fit with GENI phase 1 and beyond

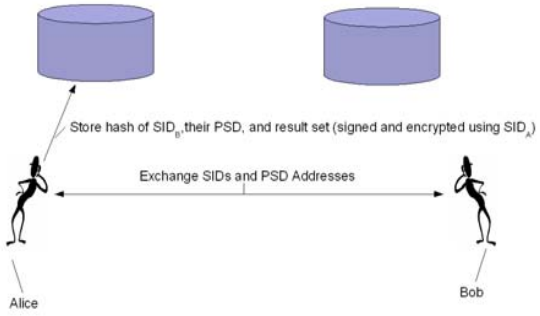
- Link CTVR Cognitive Radio Test-bed to others in Global Cognitive Radio testbed using GENI infrastructure
- Contribute equipment to Global Infrastructure
  - Software Radios, USRP-based and CTVR front-end, antennas etc
  - Global access to COMREG light-touch regulatory environment

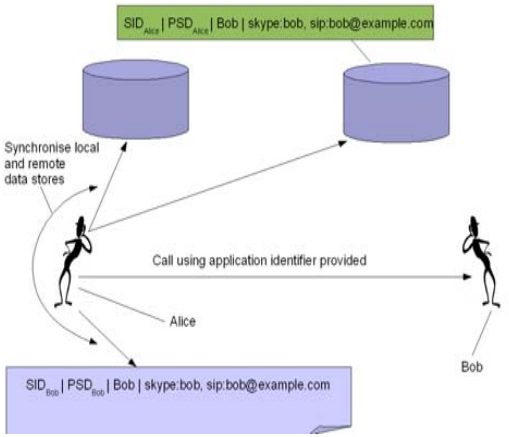
Sobriquet

- Identifier portability
  - For internet applications
- Problem
  - Provider change requires identifier change
- Solution
  - Identify people without being tied to providers

Sobriquet

- Identifiers
  - Public Keys
    - Decentralised allocation
  - Sobriquet IDs
    - Identifies users to each other
    - Exchanged out of band
  - Personal Data Store
    - Stores Sobriquet IDs, petname, and PDS location
  - Privacy concerns
    - Profiles govern use of IDs
      - Defined by users
      - Policy for how user should be contacted
    - SID changes every session
      - Requires state to be stored
      - Forward privacy



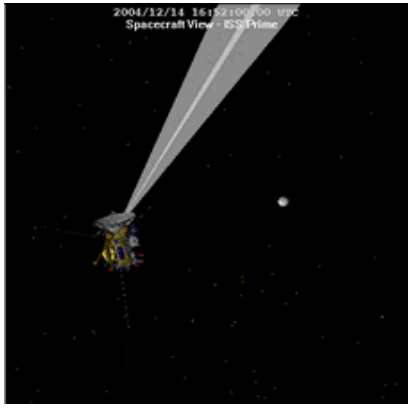


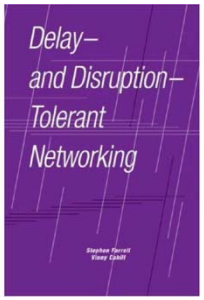
Fit with GENI phase 1 and beyond

- Able to deploy Sobriquet
- In a network that is like the internet in many ways
  - endpoints identified by numeric addresses
  - DNS functionality replaced
  - interconnect with legacy internet

Delay- and Disruption-Tolerant Networking

- Delay- and Disruption-Tolerant Networking (DTN) aims to ensure that data flows even if there is *never* any end-to-end connection
  - DTN works when TCP breaks!
- Original concept related to an Interplanetary Internet, but has now morphed to include terrestrial applications
  - Sensor nets, networking in developing regions…
- http://www.dtrng.org/





DTN and GENI

- Two angles:-
  - GENI experiments might want to explore delay and/or disruption tolerance so the GENI infrastructure should support that
    - E.g. A sensor node that only ever connects indirectly and generally once per week
  - Communications to some GENI nodes might be subject to disruption
    - E.g. As an experiment takes links up and down
- DTN protocols *might* be useful in such cases
  - E.g. To get audit data back, to push out new software
  - If not DTN protocols, then some DTN features should be useful

Summary

- CTVR is interested in being a part of GENI phase 1
- Can Contribute infrastructure/expertise in the areas of:
  - Optical Networking
  - Cognitive Radio
  - Network Architecture
  - Disruption Tolerant Networking
- Industry/Academic Links possible
- NSF/SFI or EU FP7 are possible funding sources