The BRIDGES Project-

Binding Research Infrastructures for the Deployment of Global Experimental Science

Building a Global Cyber-Infrastructure Canvas Supporting Networked Applications Experimentation and Evolution

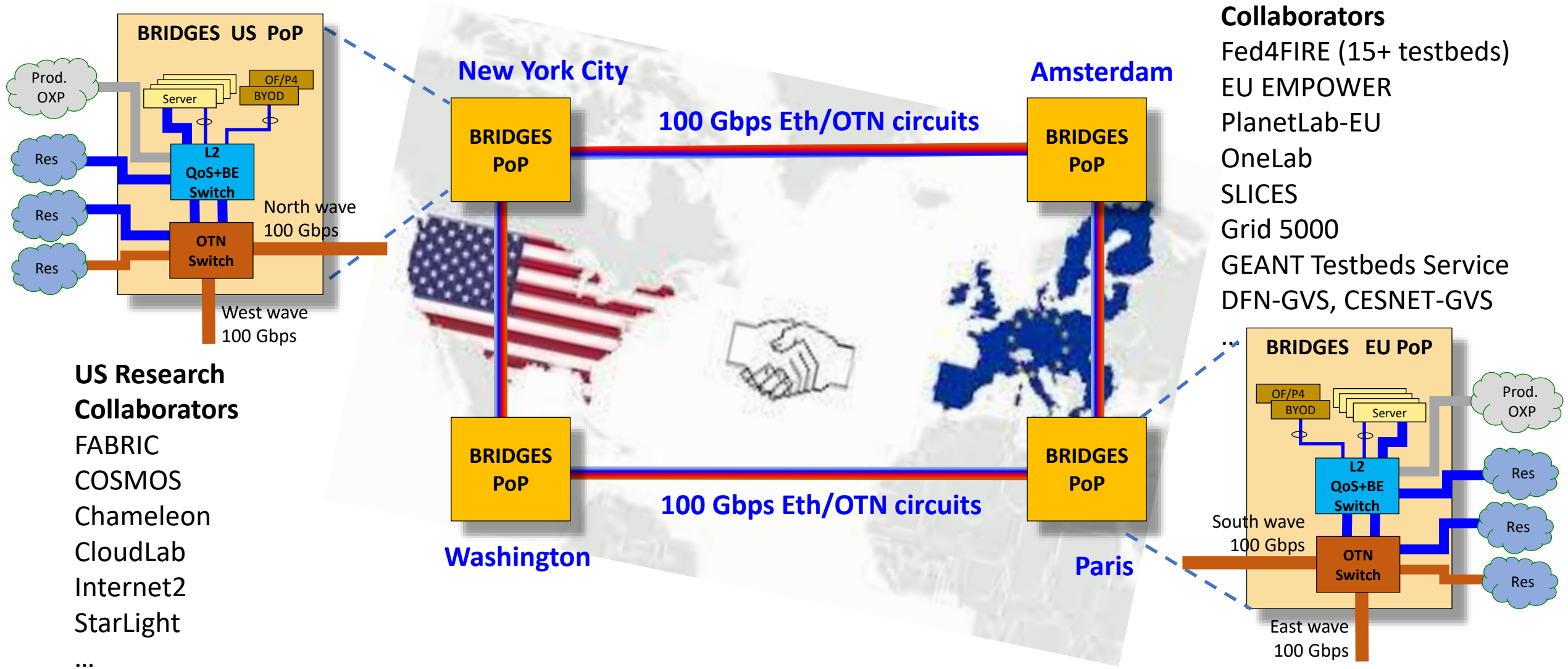
Introduction and Overview of the Project

What is "BRIDGES" ?

- Long acronym: "Binding Research Infrastructures for the Deployment of Global Experimental Science"
- Funded by the US National Science Foundation (NSF)
  - $2.5M USD, 3 years
- Part of the NSF Int'l Research Network Connections (IRNC) program "Testbeds" platforms

- BRIDGES goal is to make customized deterministic cyber-infrastructure resources available to applications globally
  - Predictable, deterministic performance – anywhere/everywhere
  - Agile and customizable to meet changing usage or application requirements
  - Globally scalable and globally secure architecture
- Start with US and European collaborators

BRIDGES- Binding Research Infrastructures for the Deployment of Global Experimental Science



US Research Collaborators

FABRIC
COSMOS
Chameleon
CloudLab
Internet2
StarLight
…

EU Research Collaborators

Fed4FIRE (15+ testbeds)
EU EMPOWER
PlanetLab-EU
OneLab
SLICES
Grid 5000
GEANT Testbeds Service
DFN-GVS, CESNET-GVS
…

Key BRIDGES Project Objectives

- Bind research infrastructures in Europe and US
  - Provide a facility that enables collaborating projects to extend advanced networking and applications architectures/concepts across the Atlantic
- Demonstrate the efficacy of a Generic Virtualization Model to deliver dynamic deterministic cyber-infrastructure resources to applications and services on a global scale
- Establish and operate a long term physical infrastructure that can support these goals

BRIDGES Project Team:

- George Mason University (Fairfax, VA)
  - Dr. Bijan Jabbari (Principle Investigator)
  - Jerry Sobieski (Co-PI)
  - GMU leads the infrastructure engineering and software deployment

- East Carolina University (Greenville, NC)
  - Dr. Ciprian (Chip) Popoviciu (Co-PI)
  - ECU heads up virtualized operational component, and is key in software development

Project Commercial Partners

- Juniper Networks
  - PoC: John Jamison (Reston, VA)
- Ciena
  - PoC: Marc Lyonnais, Rod Wilson, Lance Williford   (Ottawa, CA)
- Global Cloud Exchange
  - PoC: Daniel Minns (London, UK)

1. Collaborative Research

- The BRIDGES project is working with over 30 network and CS research projects in the US and EU. These are the initial collaborators and/or beneficiaries of the project
  - FABRIC, COSMOS, Chameleon, CloudLab, Esnet, EdgeNet, StarLight/iCAIR, Internet2, AutoGOLE
  - SLICES, Fed4FIRE, EUWireless, Onelab, 5G EMPOWER, PlanetLab-EU, Grid5000, NetherLight/SURF, SCION, UvA, GEANT, CESnet, DFN, NORDUnet
- BRIDGES PIs have broad knowledge of the European network research community and can act as liason for US projects to make intors.
- BRIDGES is seeking additional scientific applications that can benefit from highly customizable international cyber-resources
- “equitable reciprocity” – BRIDGES access policy that enables open access to projects and infrastructures in US and EU.

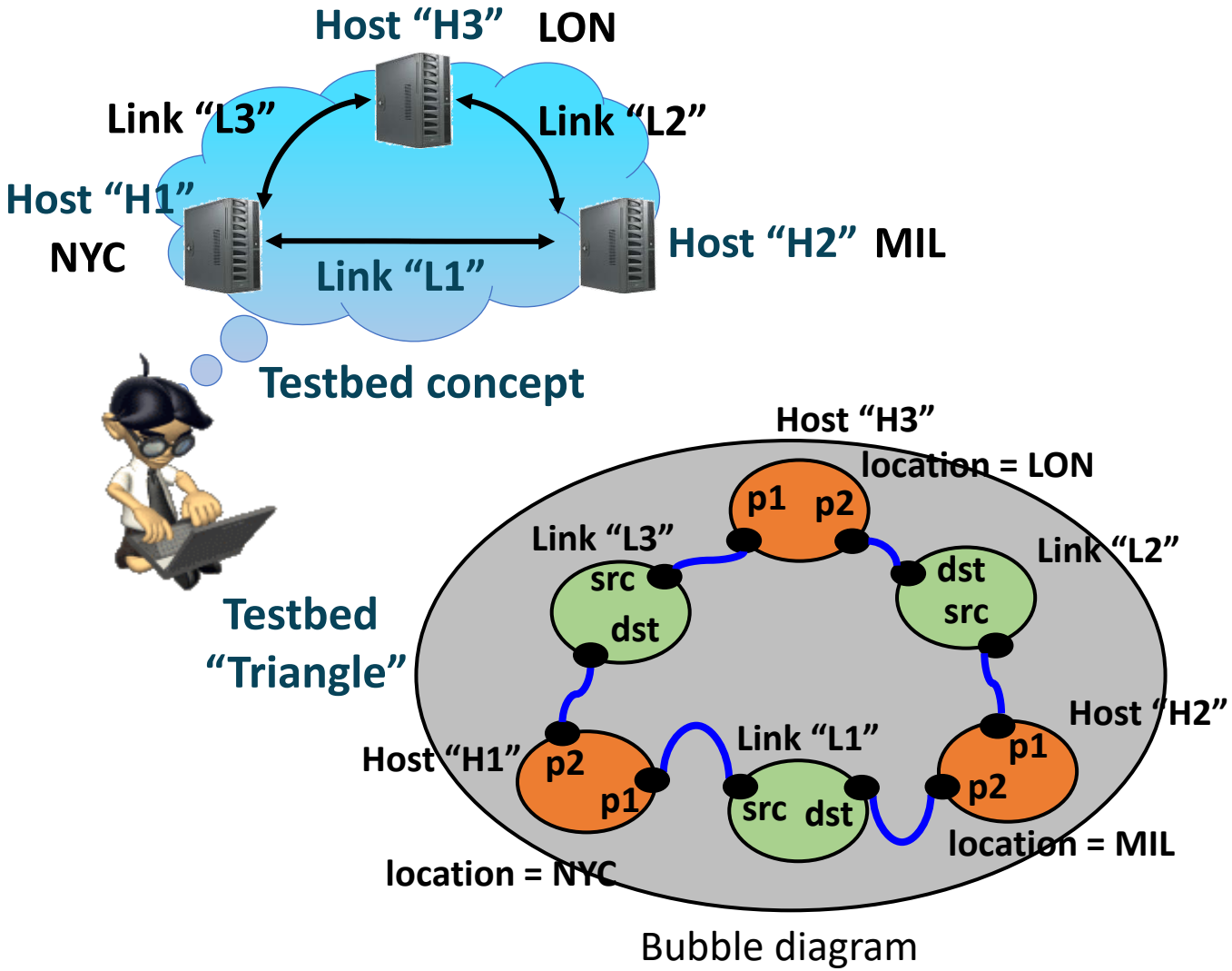
1. Collaboration

- BRIDGES goal is to offer international research programs the ability to establish a single contiguous and integrated canvas spanning North America and Europe.
  - Each community of collaborating projects will be able to define the utilize and manage their respective canvas as if it was their own physical infrastructure.
- BRIDGES collaborators will be allowed to connect physically to the BRIDGES nodes, or they can access and utilize BRIDGES through virtual resources.
  - Dynamic Virtual Resources across and within BRIDGES are the primary modus operandi
  - There are limited physical ports and tight budgets, so physical connectivity will be prioritized to enhance research reachability.

2. Virtualization as an Architecture

- BRIDGES will operate a “fully virtualized” services environment
  - All BRIDGES resources allocated to collaborating projects will be “virtual resources”
  - These resources will look and feel as if they are dedicated physical infrastructure
  - Deterministic, predictable performance, agile, customizable, integrate virtual resource model
- BRIDGES asserts that ”virtualization” is an *architectural* concept – not simply emulating hardware in software.
  - This is not simply extending cloud VMs to/into the network…
- BRIDGES supports a Generic Virtualization Model
  - All resources are *virtual* – i.e. each virtual resource is predefined with a closed set of attributes that users can tune to their applications’ requirements.
  - A set of commonly used functional resources are defined as base “atomic” resources:
    - Virtual circuits, virtual machines, virtual switches, etc.
  - More complex or specialized virtual resources can be defined through composition.
    - Composite resources can be user defined.
  - Users and applications interact with the BRIDGES virtual services environment either through an interactive web portal or via a programmatic API to enable automation and orchestration.

Describing virtual resources

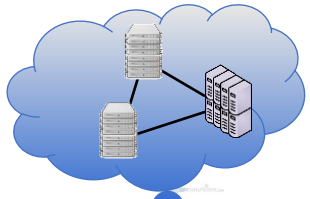


Bubble diagram

```
triangle {
  host {
    id="h1"
    location=”nyc"
    port { id=”p1" }
    port { id=”p2" }
  }
  host {
     id="h2"
     location="mil"
     port { id=”p1" }
     port { id=”p2" }
   }
   host {
     id="h3"
     location="lon"
     port { id=”p1" }
     port { id=”p2" }
  }
  link {
     id="l1"
     port { id="src" }
     port { id="dst" }
   }
 link {
     id="l2"
     port { id="src" }
     port { id="dst" }
   }
  link {
     id="l3"
     port { id="src" }
     port { id="dst" }
   }

   adjacency h1.p1, l1.src
   adjacency h2.p2, l1.dst

   adjacency h2.p1, l2.src
   adjacency h3.p2, l2.dst

   adjacency h3.p1, l3.src
   adjacency h1.p2, l3.dst

}
```

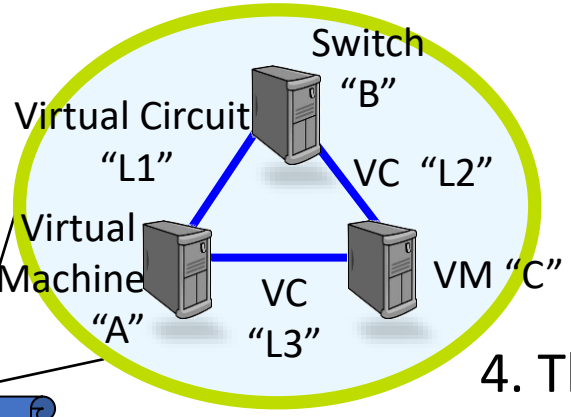
Done.

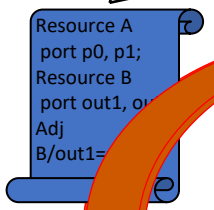
2. Network conceived to test brilliant idea



1. Researcher has a brilliant idea

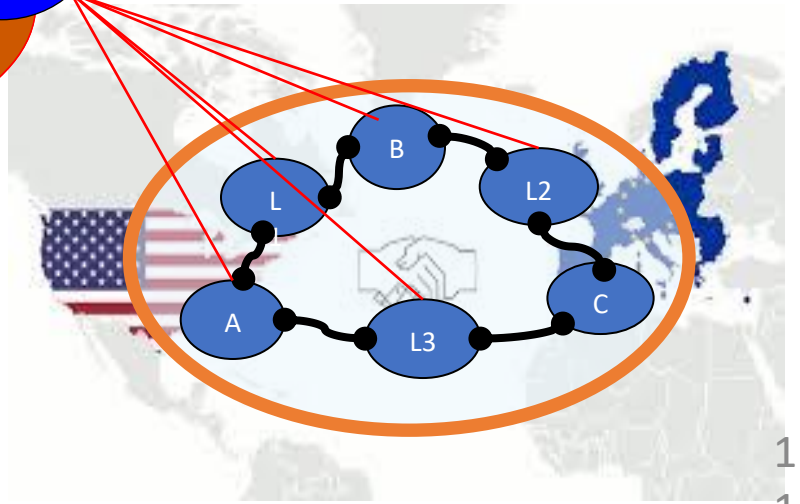
3. Researcher logs in, describes a testbed using a web GUI





4. The User Agent sends the testbed description to GTS using the GTS API

5. The GTS Provider Agent finds and reserves resources for the testbed



6. Resource ID information is returned to the user and user controls the testbed via the User GUI and other GTS API primitives

Key Software Features to be Developed or Refined

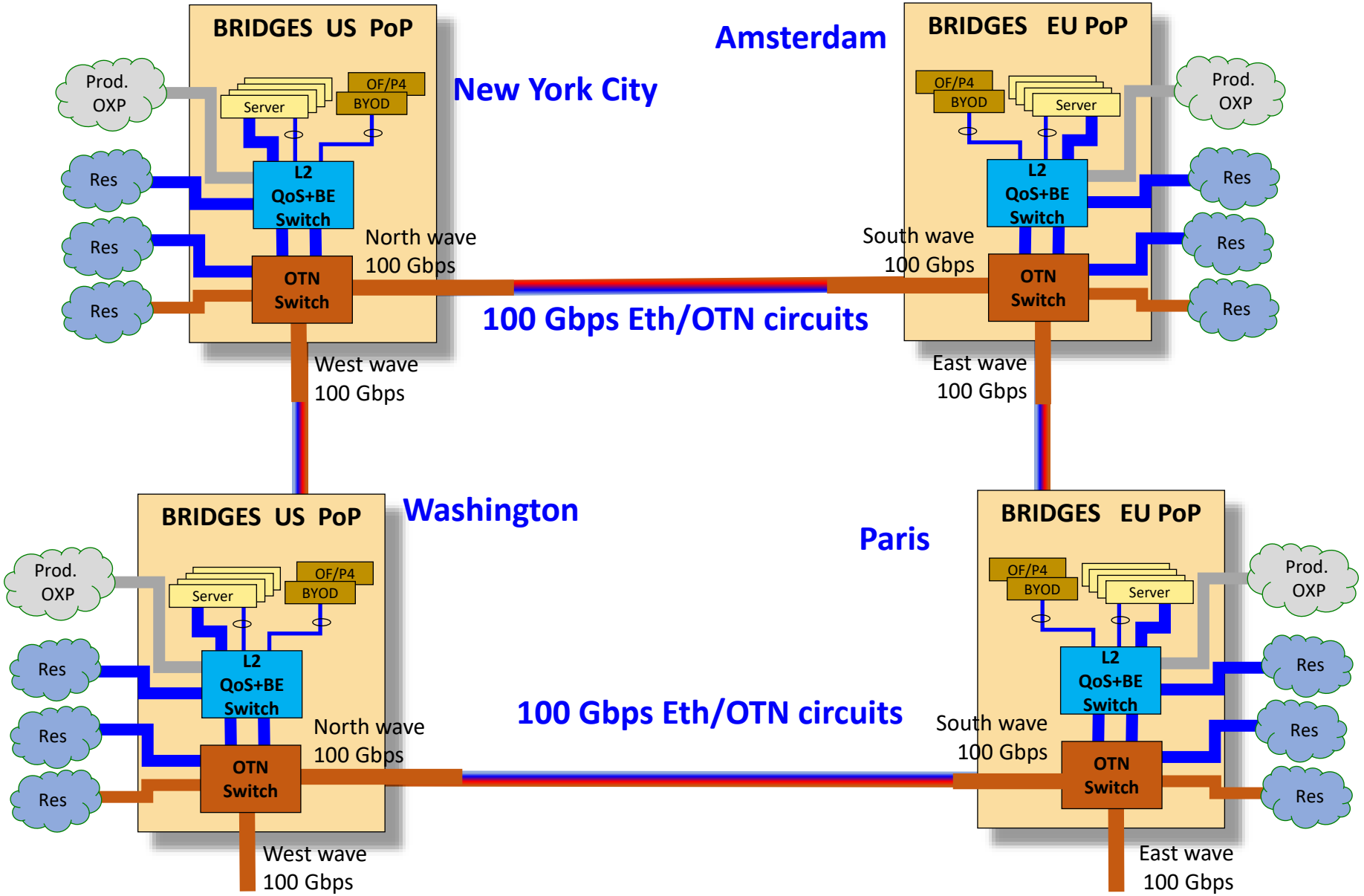
- Simplification – reduce the complexity of deployment, configuration, and operational management
- Federation – this relieas upon:
  - Multi-Domain+Transparency – ability to allocate resources from/across many administrative domains transparently into an integrated user environment
  - Scalable Policy Engine – to allow domains to better manage their available resources across many global user communities.
- Advanced mapping algorithms for optimization (placement, migration, and grooming) of virtual resources across physical infrastructure and multiple policy domains.
- Explore sensor virtualization
- Enhanced 5G virtualization

3. Infrastructure: The Ring

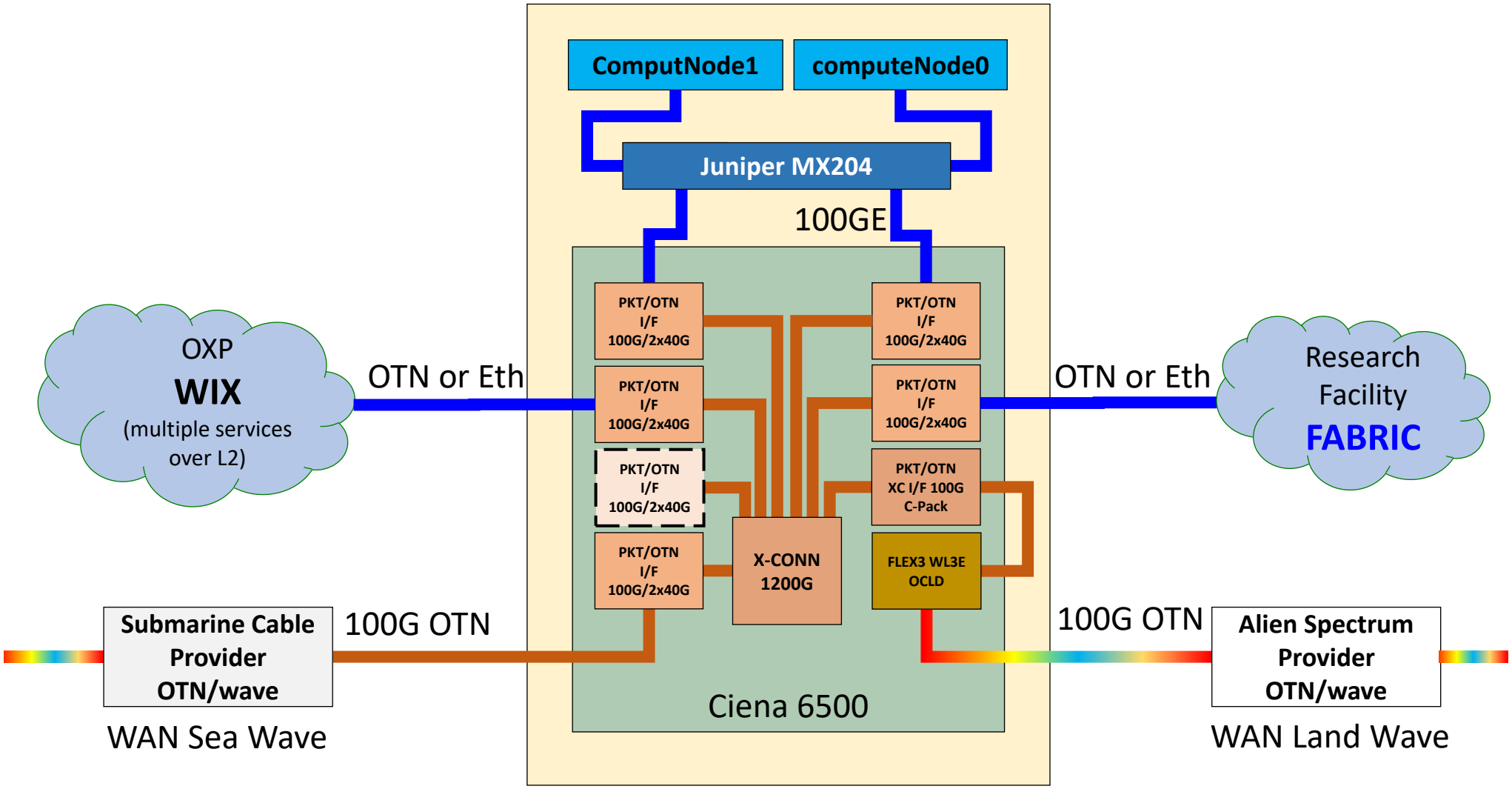
- Four “Nodes” connected by four 100 Gbps waves.
  - Washington, DC US (Equinix Ashburn, VA)
  - Paris, FR (Interaxion)
  - Amsterdam, NL (NetherLight/SURFnet)
  - New York City, NY US (MANLAN)
- Each node is in a BRIDGES dedicated rack using BRIDGES dedicate equipment, completely managed by the BRIDGES project
  - Nodes are collocated with global R&E exchange points to facilities physical X-connects when/where needed.
- The Waves are all 100 Gbps ETH/OTN framing.
  - Allows link concatenation u, to 200 Gbps and deterministic performance
  - Trans-ATL waves are 10 yr IRU from WDC-PAR, and from NYC-AMS. (GCX provider)
  - Land waves are dim spectrum from WDC-NYC (I2) and AMS-PAR (SURFnet)

- *BRIDGES is an experimental Testbed*
  - How BRIDGES is applied to support science applications and other research is fully under control of the BRIDGES program.

3. Infrastructure: The Ring



3. The Infrastructure: The Nodes



Timeline.

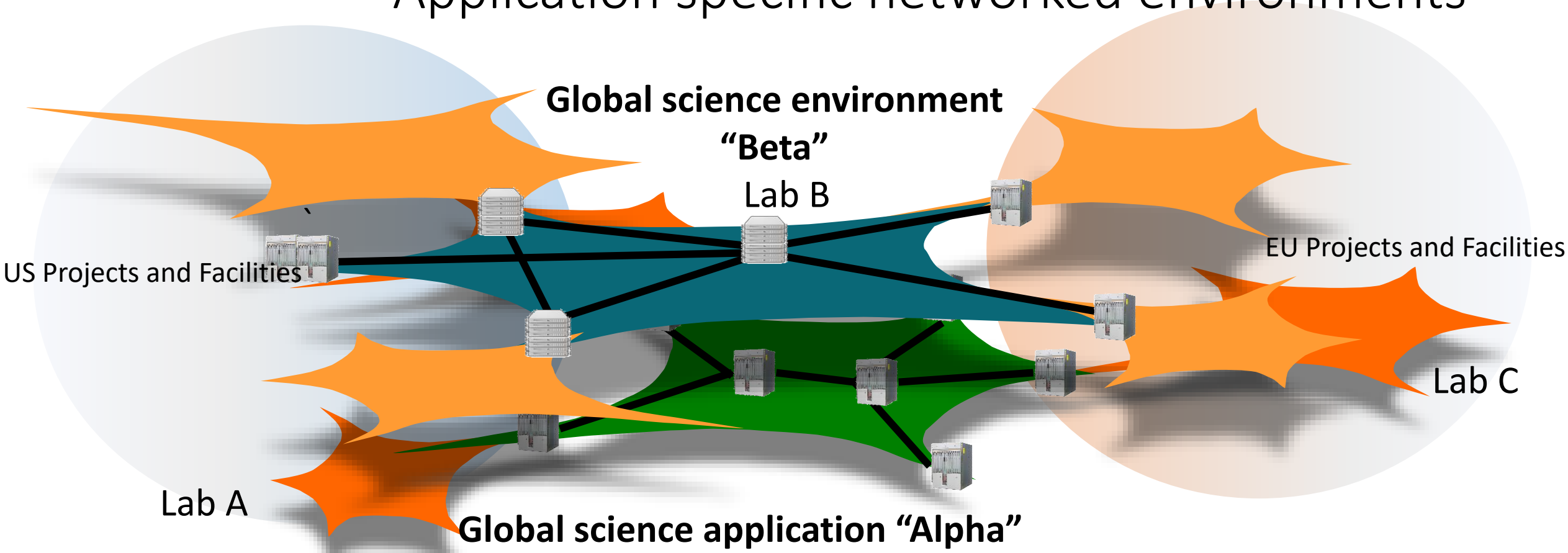
- BRIDGES is a 3 yr Project.
  - Year 1 Oct 2020 – Sep 2021
    - Build out Washington and Paris nodes and Trans-Atlantic wave
    - Deploy GVS software
    - First connectors Q2/Q3 2021
    - Target In-Service date ~Jul 2021
  - Year 2. Oct 2021 – Sep 2022
    - Build out Amsterdam and New York pops and terrestrial optical links in US and EU
    - Target In-Service dates Jan-Mar 2022
    - Deploy second 100 Gbps wave. NYC-AMS
    - More connectors, More software features
  - Year 3 Oct 2022 – Sep 2023
    - NYC-AMS wave In-Service :Jan 2023. Ring closed.
    - Software focus – new features

Conclusion: Key BRIDGES Concepts

- Network research and global applications require a very flexible, agile, and deterministic cyber-infrastructure environment in order to innovate, evaluate, and evolve.
- Cyber-infrastructure is going virtual and software processes are critical to managing these CI resources. But automation and orchestration of CI, and the integration of different CI elements is dependent upon a common model for defining and manipulating these virtual resources – a Generic Virtualization Model.
- BRIDGES supports the notion that networks and applications can be dynamically constructed from virtual CI resources – IFF those CI resources are defined and implemented rigorously, and a common grammar exists for manipulating such resources via software driven processes.
- In order to develop dynamic *global* applications and application specific service environments, a generic virtualization model is key, and a facility that can fully implement that virtualized resource model is required.
- BRIDGES provides the infrastructure and the virtualization layer software to do this.

BRIDGES Virtual Network Architecture

Application specific networked environments



A customized WAN infrastrcuture consisting of a broad range of dynamically allocated resources that are controlled by the client using SDN principles

Looking Forward

- The BRIDGES concept envisions a future integrated global CI environment in which dynamic and deterministic “virtual” cyber-resources become the standard coin of the realm.
  - Instead of physical infrastructure, networks are constructed from virtual resources that offer secure, predictable, and reliable performance and that can be allocated or modified as requirements change.
- BRIDGES would like to extend the BRIDGES US-EU architecture to support other national and international deployments, incrementally extending the experimental virtualized canvas to a global reach

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