

WHERE ARE WE GOING WITH BANDWIDTH ON DEMAND SYSTEMS ?

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Around BoD

- ⦿ Migration of academic networks to fibers & optical technologies
- ⦿ Offer of the **E2E services** – including LAN / MAN / NREN / inter/continental networks
- ⦿ Services are available **now** with **high SLA** and **secured privacy**
- ⦿ **Wide granularity** of services (from single Mb/s to dedicated lambdas)

but

- ⦿ Existing capacities / economic conditions of academic networks limit the user requirements
- ⦿ Complexity of networks (including multi-domain issue)

BoD systems developed in research community

1. G-Lambda
2. Dragon/OSCARS
3. Enlightened Computing
4. AutoBAHN
5. ARGIA
6. MANTICORE
7. PHOSPHORUS-G2MPLS
8. PHOSPHORUS-HARMONY
9. ARGON
10. CARRIOCAS SRV

BoD systems features

- ⦿ Layers ISO/OSI supported by the software
- ⦿ The inter-domain feature supported
- ⦿ Advance reservations
- ⦿ Switching granularity
- ⦿ Interfaces / API
- ⦿ Supported hardware
- ⦿ Type of license
- ⦿ Additional specific features

Layers ISO/OSI supported by the software

G-Lambda	Layer 1/ Layer 2 (the interface can support labelling schemes including VLAN as a parameter)
Dragon/OSCARS	Layer 1/ Layer2 (particulary Ethernet over SONET, Ethernet over MPLS, Ethernet)
Enlightened Computing	Layer 1, Layer 2
AutoBAHN	Layer 1 (SDH), Layer 2 (Ethernet, Ethernet/MPLS)
ARGIA	Layer 1 / Layer 2 (partial - no dynamic vlan management)
MANTICORE	Layer3 (The MANTICORE-II project looks beside enhancing 'MANTICORE' also to interwork with the ARGIA and ETHER services – Layer1 and Layer2)
PHOSPHORUS-G ² MPLS	Layer 1 (LSC, FSC), Layer 2 (Ethernet)
PHOSPHORUS-HARMONY	Layer 1 / Layer 2 (partial - no dynamic vlan management)

Layers ISO/OSI supported by the software

ARGON	<p>Layer 2:</p> <ul style="list-style-type: none">• E2E Ethernet tunnels via MPLS/VPLS and GMPLS• VLAN and port configuration• Traffic shaping <p>Layer 3:</p> <ul style="list-style-type: none">• E2E IP tunnels via MPLS• Mapping of IP packets to MPLS tunnels• Traffic shaping
CARRIOCAS SRV	<p>Layer 1 (Lambda switching)</p> <p>Layer 2 (Ethernet)</p>

The inter-domain feature supported

G-Lambda	YES (inter-domain demo with EnLIGHTened used wrappers, adaptor to Fenius (formally GUSI) available)
Dragon/OSCARS	YES
Enlightened Computing	YES
AutoBAHN	YES
ARGIA	NO (It needs Harmony on top for inter-domain signalling)
MANTICORE	YES (it use resources from many domains and offer them as single domain resource)
PHOSPHORUS-G ² MPLS	YES (Grid-augmented OIF E-NNI signalling + routing, with inter-carrier support (e.g. AuthZ))
PHOSPHORUS-HARMONY	YES (signalling implemented for both resource reservation and topology sharing)
ARGON	NO (It needs Harmony on top for inter-domain signalling)
CARRIOCAS SRV	Work in progress

Advance reservations (1)

- **Advance reservation** (AR) is a reservation scheduled for future (non-instantaneous) execution.
- The requestor of the connection service is obliged to specify information when to create and discard the circuit. Depending on access interface, it can be provided in two ways:
 - **Start time** and **duration** of the reservation, which guarantees that reservation will be available for specified period of time
 - **Start time** and **end time**, which will make the system to tear down the circuit at specified time in the future
- Since reservation request arrives to an ingress domain, it is expected that circuit feasibility check will be performed basing on the available network knowledge at current moment
 - Issue:
 - booked resources and defined paths are loaded with the **risk of failure** at **circuit creation time**
 - Solutions/Suggestions:
 - **Network monitoring** is a strong requirement for advance reservations
 - Reservation may involve **multi-domain** and **heterogeneous** aspects, the failure prevention activity should include **policy issues** (hiding domain internals), **efficient communication protocols** (for notifications), and **reliable issues solving actions** (path recalculation, resources re-negotiations, crankback, etc.)

Advance reservations (2)

- ⦿ Calendars for maintenance of resource bookings are required. Popular solution is to have:
 - **Centralized calendars** for single domain
 - **Distributed calendars** for multi-domain
- ⦿ For multi-domain purposes calendar **synchronization** between peering domain is required
 - As domain may be represented by abstracted topology, its internals should be also abstracted in calendar
 - At least resources for inter-domain links should be advertised for neighbouring calendar entities

Advance reservations (3)

G-Lambda	YES , fixed and malleable
Dragon/OSCARS	YES
Enlightened Computing	YES
AutoBAHN	YES
ARGIA	YES , fixed and malleable
MANTICORE	NO
PHOSPHORUS-G ² MPLS	YES , fixed, fully distributed (OSPF calendars + crankback)
PHOSPHORUS-HARMONY	YES , fixed, deferrable, malleable
ARGON	YES , fixed, deferrable, malleable
CARRIOCAS SRV	YES

Switching granularity (1)

- ⦿ Connections in networks can be categorized according to their switching granularity
- ⦿ Granularity may range from best-effort IP packet networking to granularity of a single or group of wavelengths
- ⦿ Just an example for optical networks:
 - Fiber switching,
 - Wavelength switching,
 - Optical Burst Switching,
 - etc., ...

Switching granularity (2)

G-Lambda	Depends on technology, in general any bandwidth value can be requested (typical value is 1Gbps)
Dragon/OSCARS	50 Mbps (STS1) on Internet2, 1Mbps in ESnet and regional/campus networks
Enlightened Computing	Lambda, port
AutoBAHN	Depends on technology, in general any bandwidth value can be requested (typical values are 1Mbps, 1Gbps)
ARGIA	Lambda, port, SDH/Sonet slot, VLAN (partially)
MANTICORE	The MANTICORE services provides an IP routing
PHOSPHORUS-G ² MPLS	LSC (WDM), FSC (port switching), VLAN (partially)
PHOSPHORUS-HARMONY	Lambda, port, VLAN (partially), LSP (variable BW, Mbps scale)

Switching granularity (3)

ARGON	Layer 2: based on interfaces Layer 3: based on traffic shaping capabilities -- implemented in Argon v1, now to be ported to Argon v2
CARRIOCAS SRV	Lambda, Ethernet VLANs

Interfaces / API (1)

- ◎ Cooperation with other systems:
 - via Web-Services,
 - via other interfaces.

- ◎ Programing API
 - Web-Services,
 - Corba,

Interfaces (2)

G-Lambda	<ul style="list-style-type: none">• GNS-WSI3 (the interface between network resource manager and upper layer middleware)
Dragon/OSCARS	<ul style="list-style-type: none">• Interface to HARMONY (WebService – experimental)• IDC interface implementation between I2 and ESNet, GN2 (AutoBAHN), NetherLight, CENIC/CalTech, NYSernet, LEARN, LONI, MAX, Northrup Grumman
Enlightened Computing	<ul style="list-style-type: none">• Interface to G-Lambda• Web-services
AutoBAHN	<ul style="list-style-type: none">• Interface to DRAGON/OSCARS• IDC interface implementation
ARGIA	<ul style="list-style-type: none">• No native inter-domain capabilities. Needs Harmony on top for signalling to external domains.
MANTICORE	<ul style="list-style-type: none">• Web services

Interfaces (3)

PHOSPHORUS-G ² MPLS	<ul style="list-style-type: none">• CORBA management interfaces• Augmented OIF UNI2.0 and E-NNI (G.RSVP-TE and G.OSPF-TE)• HARMONY (WS)• UNICORE (WS)
PHOSPHORUS-HARMONY	<ul style="list-style-type: none">• HARMONY-IDC: currently using IDC protocol v0.4• HARMONY-G-LAMBDA/EnLIGHTened: not supported• HARMONY-AutoBAHN: feasible using IDC protocol (not tested)
ARGON	<ul style="list-style-type: none">• Interface to the VIOLA MetaScheduler• Interface to the PHOSPHORUS Harmony IDB• JMS interface support• Limited telnet CLI management support
CARRIOCAS SRV	<ul style="list-style-type: none">• MTOSI interface towards the equipment• NSI interface support (on-going)

Programing API (4)

G-Lambda	Web-services, WSDL available
Dragon/OSCARS	Web-services
Enlightened Computing	Web-services
AutoBAHN	Web-services
ARGIA	Available upon request. Compatible with Harmony API/client.
MANTICORE	Available upon request
PHOSPHORUS-G ² MPLS	<ul style="list-style-type: none">• CORBA• WS via G.UNI-GW• UNI RSVP and OSPF
PHOSPHORUS-HARMONY	API available under GPL license. Also available Harmony Service Interface (HSI) client libraries, for integration with other systems or inside applications.

Programing API (5)

ARGON	Not officially released yet.
CARRIOCAS SRV	<ul style="list-style-type: none">• Virtual Resources and Interconnection Networks Description Language (VXDL)• Web Services

Supported hardware (1)

- ◎ Type of devices
 - Lambda switching (LSC)
 - Fibre switching (FSC)
 - Ethernet (Eth)
 - SDH/SONET
 - IP routers

Supported hardware (2)

G-Lambda	Implementation dependent. AIST NRM supports NTT electronics OXC and Dell PowerConnect 5224. Implementation of NRMs by telcos are not disclosed.
Dragon/OSCARS	<ul style="list-style-type: none">• Dell PowerConnect 5224/5324• Dell PowerConnect 6024/6024F• Dell PowerConnect 6224• Extreme Summit 1i/5i• Intel Express 530T• Raptor ER-1010• Cisco Catalyst 3750, 3750-E• Cisco Catalyst 6500• HP ProCurve 5406• SMC 8708L2• SMC 8848M• Juniper EX3200, EX4200• Force10 E300, E600, S50V• Force10 S2410• Netgear GSM7224• Linux Software Switch• Ciena CoreDirector (Ethernet-over-SONET Subnet)

Supported hardware (3)

Enlightened Computing	<ul style="list-style-type: none">• Calient DiamondWave FiberConnect PXC• Cisco ONS 15454 Cisco• Cisco 6500 series
AutoBAHN	<ul style="list-style-type: none">• Plugins for NMS systems are preferred, rather than direct HW support• Technology proxies are available for Alcatel NMS (DANTE)• BlueNET Ethernet/MPLS management system (HEAnet)• ASNTool for Ethernet technology management (GRNET)• Support for Foundry Networks equipment (PIONIER)• Support for any hardware type/NMS can be easily added
ARGIA	<ul style="list-style-type: none">• Allied Telesis AT-8000S series• Calient DiamondWave FiberConnect PXC• Cisco ONS 15454 Cisco• Catalyst switches (several series)• Cisco 6500 series• Nortel HDXc• Nortel OME 6500 (several interface cards supported)• Nortel Optera Metro 5200• W-Onesys Proteus

Supported hardware (4)

MANTICORE	<ul style="list-style-type: none">• Juniper routers,• Cisco Nexus platform• PC-based routers (XORP)
PHOSPHORUS-G ² MPLS	<ul style="list-style-type: none">• LSC: ADVA FSP 3000RE-II• FSC: Calient Diamond Wave• FSC (Ethernet): Allied Telesis AT-8000/S• FSC (Ethernet): Allied Telesis AT-9424T• FSC (Ethernet): Foundry XMR NetIron 8000• LSC/FSC hardware emulator• LSC: ADVA ROADM emulator
PHOSPHORUS-HARMONY	Harmony is not directly interfacing the equipment, but with Network Resource Provisioning systems, Network Management systems or control planes.
ARGON	<ul style="list-style-type: none">• Riverstone 15008 (VLAN, MPLS, VPLS)<ul style="list-style-type: none">• Accessed via CLI and SNMP.• Alcatel 1678 (Ethernet, GMPLS)<ul style="list-style-type: none">• Accessed via CLI and SNMP.
CARRIOCAS SRV	All MTOSI compatible NMS

Type of license (1)

- ◎ Software licences define usage and/or redistribution of software
- ◎ In general, there are two types of licenses:
 - Free/open source licences
 - Proprietary licenses
- ◎ For the discussed BoD systems, mostly Open Source licensing is used which allows to use and modify the source code

Type of license (2)

G-Lambda	Apache license
Dragon/OSCARS	A modified BSD license
Enlightened Computing	Open Source code BSD-like
AutoBAHN	Open Source code, GN2 license
ARGIA	Several licenses apply, depending on service. Chronos uses ASL.
MANTICORE	Open source code, ASL
PHOSPHORUS-G ² MPLS	GPLv2 for most of the stack modules
PHOSPHORUS-HARMONY	GPLv2 or EUPL/LGPL (to be decided)

Type of license (3)

ARGON	Not officially released yet.
CARRIOCAS SRV	Proprietary

Additional features

G-Lambda	<ul style="list-style-type: none">• Support of computing resources
Dragon/OSCARS	<ul style="list-style-type: none">• VLAN translation on Ciena CoreDirector networks
Enlightened Computing	<ul style="list-style-type: none">• allocation of grid resources• monitoring• Recovery procedures
AutoBAHN	<ul style="list-style-type: none">• AutoBAHN is a multi-domain framework, single domain management is implemented independently for each domain,• flexibility in integration with local domain HW/SW
ARGIA	<ul style="list-style-type: none">• modular service implementation,• compatible with IaaS framework solutions.
MANTICORE	<ul style="list-style-type: none">• integrates open AuthN/AuthZ infrastructure,• User and administrative Web GUI available,• easy integration for other IaaS systems,• service plane is fully reconfigurable, no need for operation modes

Additional features (2)

PHOSPHORUS-G ² MPLS	<ul style="list-style-type: none">• uniform interface for the Grid-user to trigger Grid & network resource actions• single-step provisioning of Grid and network resources• <i>Overlay</i> G²MPLS model: unicast BoD services with advertisement of Grid resources through the Network Control Plane• <i>Integrated</i> G²MPLS model: anycast BoD services, specifying “GNS TNAs”• Augmented PCE support: network + grid resources computation• interfaces the Grid Middleware (Unicore 6)
PHOSPHORUS-HARMONY	<ul style="list-style-type: none">• interfaces the Grid Middleware (Unicore 6),• integrates open AuthN/AuthZ infrastructure (using G-AAA toolkit),• administrative Web GUI available,• easy integration for other systems, using adaptor model,• service plane is fully reconfigurable,• several operation modes are available: centralised, hierarchical, distributed, daisy chain and hybrid.

Additional features (3)

ARGON	<ul style="list-style-type: none">• interfaces to Grid middleware: see Interfaces (3).• support of fixed, deferrable and malleable advance reservations
CARRIOCAS SRV	<ul style="list-style-type: none">• IT resources & services supported

Summary

- ⦿ A need for a common approach towards a generic standards-based framework, allowing smooth integration and interoperability of abovementioned systems
 - A generic network interface (called by external entity: end user, middleware, network/service providers)
 - Recommendations for procedures and protocols
 - A number of issues to be solved:
 - Technology stitching
 - Interoperability at the Control Plane level
 - AAA, etc.
- ⦿ The **NSI WG** has been established to address some of the issues. The goals include:
 - A specification of the NSI architecture
 - A message definition and protocol specifications
- ⦿ The NSI will create a set of recommendations to facilitate interoperation between Grid users, applications and network infrastructures spanning different service domains

Questions?