Transforming next-gen optical networks with TIP’s Cassini solution

Come learn how the industry collaboration deployment for the first disaggregated optical networks in Latin America. In the webinar, we’ll introduce how telecommunication providers can increase its network capacities for major cities by deploying the new software-defined IP network based on the industry’s first open optical packet transponder – Edgecore hardware with OcNOS® from IP Infusion, led the first trial by Whitestack in Latin America.
Speaker Introduction

Dave Hutton  
Chief Architect

Matt Roman  
VP of Product Management and Marketing

Srikanth Krishnamohan  
Director of Product Marketing

José Miguel Guzmán  
Sr. Network Consultant
TIP Overview

Hardware Overview - Edgecore

Software Overview - IP Infusion

Deploying Cassini in the Real World - Whitestack

Q&A
Together We Build, Test and Deploy

Telecom Infra Project

David Hutton
Chief Engineer, TIP
## THE OPPORTUNITY

Improving connectivity will unlock substantial economic value

### Connectivity has the potential to unlock substantial value

**Impact of “advanced connectivity” on global GDP (2030E)**

<table>
<thead>
<tr>
<th>New connectivity use cases</th>
<th>Connecting the unconnected</th>
<th>New connectivity use cases</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>$12 - $2.0 trn</td>
<td>$1.5 - $2.0 trn</td>
<td>NA</td>
<td>&gt;$2.7 - $4.0 trn</td>
</tr>
</tbody>
</table>

4 selected domains:
- Healthcare
- Manufacturing
- Mobility
- Retail

Enabling 1bn people to gain better access to digital information, tools & services

Other domains

### COVID-19 is accelerating the need for better connectivity

**Growth in US consumer internet traffic (Mar-Jun 2020)**

- Upstream
- Downstream

What is TIP?

Founded in 2016, TIP is a community of diverse members that includes hundreds of companies - from service providers and technology partners, to systems integrators and other connectivity stakeholders.

We are working together to develop, test and deploy open, disaggregated, and standards-based solutions that deliver the high quality connectivity that the world needs - now and in the decades to come.

Together We Build, Test & Deploy.
WHAT WE ARE BUILDING TOGETHER

To eliminate barriers and accelerate, we are working across all phases of the product lifecycle.
TIP Project Groups

- OpenOptical & Packet Transport
- vRAN Fronthaul
- WiFi
- Non-Terrestrial Connectivity Solutions
- OpenCellular
- Wireless Backhaul
- OpenRAN 5G NR
- Open Core Network
- OpenRAN
- Edge Application Developer
- End to End Network Slicing

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Open Optical & Packet Transport

Project group Scope
Open Optical & Packet Transport

Subgroups Overview

Networking Operating Systems (OOPT - NOS)
Converged Architectures for Network Disaggregation & Integration (CANDI)
Control, Information Models and APIs (CIMA)

- Disaggregated Cellsite Gateways (DCGS)
- Disaggregated Open Routers (DOR)
- Physical Simulation Environments (PSE)
- Disaggregated Optical Systems (DOS)

Current structure of the OOPT Project Group

Optical Planning Tool

OLT
Cell Site Gateway
4G/5G eNodeB
Enterprise CPE

Aggregation Router
Transponder
Amplifier
ROADM
Core Router
Mobile Core

INTERNET

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Cassini Open Packet Optical Transponder

The plan and Activities

Idea
2018 Q1

HW/SW Partner Alignment
2018 Q3

Build
2019 Q1

Design

Lab & Field Trials

General Availability
2019 Q2
2019 Q3
2019 Q4

TODAY

Production Deployments
2020
Disaggregated Optical Systems
Open and Disaggregated Transponders
Cassini Hardware Overview
Cassini Use Cases

Data Center Interconnect

Service Provider Backhaul

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What is Cassini?

• Open Disaggregated Packet Optical Transponder
• High Performance Ethernet Switch with Coherent Optical Modules
• Modular “Pay as you Grow” Design
• Choice of CFP2 Optical Technologies from Multiple Vendors
• Choice of Commercial and Open Source Software Options
• Designed and Contributed to TIP by Edgecore
Cassini Overview

Cassini Disaggregation

Disaggregation between the hardware and NOS also disaggregation in the optical layer
Cassini AS7716-24SC

• Integrated Switching and Layer 1 Optical transport functions
• 3.2 Tbps Ethernet Switch ASIC
• 16 100G Ethernet fixed ports
• 8 Module Slots for Ethernet QSFP28, DCO, or ACO Coherent Optics Line Cards
• x86 CPU
Cassini Architecture

Broadcom XGS 3.2Tb/s Switch ASIC

Intel Broadwell-D1518 4-Core CPU
16GB DDR
32GB SSD Storage
Cassini AS7716-24SC

50-Watt Power Budget per Line Card

3+1 High Power Redundant Fans
1+1 Redundant 1000W Power
AC and DC Options
0°C to 45°C Degree Celsius Operation
44.25 x 55.0 x 6.6 cm
Cassini Client Side

• 16 x 100G QSFP28 Ports
• Each 100G QSFP28 Interface Supports
  • 1x100G
  • 4x25G
  • 1x40G
  • 1x40-to-4x10G
Cassini Line Side

- Dual 100G Ethernet with MACSEC
- 100G/200G CFP DCO with MACSEC
- 100G/200G CFP2 ACO
- Field Upgradeable
- Hot-Swap
Cassini Line Cards

**Ethernet Line Card**
- 2x100Gbe
- MACSEC PHY with AES 256 Bit Encryption

**Digital Coherent Optic (DCO) Line Card**
- 1x 100G/200G CFP2
- MACSEC PHY with AES 256 Bit Encryption
- Optics - Lumentum

**Analog Coherent Optic (ACO) Line Card**
- 1x 100G/200G CFP2
- NTT Electronics ExaSPEED 200 DSP
- QPSK mode/100Gbps for maximum 1000KM
- 16QAM mode/200Gbps for maximum 200KM

**CFP2 Pluggables**
- Acacia
- Lumentum
- Fujitsu
Cassini AS7716-24SC Software

• Ships with
  • ONIE
  • ONL/ONLP running with Broadcom SDK and NEL SDK
• NOS Options
DISAGGREGATED PACKET TRANSPONDERS BASED ON TIP-CASSINI
IP Infusion: Common Platform, Variety of Use Cases

- **Multiservice Access**
  - PON
  - uCPE
  - CSR

- **Multi-layer Aggregation**
- **Metro Access/Transport**
  - Packet-Optical

- **Carrier Core**
  - Packet-Optical
  - CE, CSR, PE, PON

- **Service Consolidation**
  - Internet

- **Multi-Cloud Access**
  - Public Cloud

- **IP/MPLS**
  - PE

- **Carrier Cloud**

Legend:
- CE: Carrier Ethernet
- CSR: Cell Site Router
- PE: Provider Edge
- PON: Passive Optical Network
- uCPE: Universal CPE
Network Transformation and Trends

On-demand, any-to-any connectivity
With 5G up to 1G bandwidth to every device

Network Edge is key to the transformation
Investing for higher bandwidth to the users

DCI Expansion and growth
Double digit bandwidth growth

Successful transformation requires efficient scaling of network capacity and better automation to reducing OPEX
Bandwidth Growth

Telecom transceivers as proxy for bandwidth demand growth

- Historical YoY growth from 20–50% per year
- Modeling even conservative 20–40% growth drives need for 400G+ technologies to efficiently manage future network requirements
- 400G+ forecast to support ~ 50% of the deployed bandwidth by 2022
- 400G+ needed to reduce the cost per bit for coherent transport

Source: IHS Markit | Technology, now part of Informa Tech, Telecom Optics & Components Market Tracker; October 2019

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Disaggregated Optical Transport Solution – Ecosystem

Flexible, Open, Pluggable

Solution Ecosystem

Design and Validation:

Network Operating System:

Cassini Hardware:

Coherent Optics:

System Integrator(s):
OcNOS: Optical Transport Network (OTN) – Solution Overview

- Optical transport for the following use case:
  - Data Center Interconnect
  - Backhaul of access edge services
  - Metro Ethernet services
  - Long haul using ACO with appropriate DSP

- Feature Overview
  - L1 cross connect for transponder use case
  - L2/L3 switch for packet transponder applications
  - Configuration, monitoring and debug of optical line
  - Open API and management interfaces

- Software SKUs
  - **OCNOS-OTN-IPBASE**: L2/L3 switching with transport
  - **OCNOS-OTN-XCONNECT**: L1 cross connect for transponder use case
  - **OCNOS-OTN-CFP2-WDM**: Pay-as-you-grow model
# OcNOS OTN Key Features

<table>
<thead>
<tr>
<th>Description</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form factor</td>
<td>Modular chassis with Coherent pluggable cards. Choice of ACO or DCO optics. 200G or 100G DWDM</td>
</tr>
<tr>
<td>Distances</td>
<td>Metro to Longhaul 100Km to 1000Km+</td>
</tr>
<tr>
<td>NOS Features</td>
<td>OcNOS with comprehensive L2/L3/Multicast/VXLAN features or a L1 transponder design</td>
</tr>
<tr>
<td>Configuration</td>
<td>Modulation: DP-16QAM, DP-8QAM, DP-QPSK Output power (dBm) Frequency (Hz)</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Current pre-FEC BER (bps), current post-FEC (bps) Current input power (dBm), current output power (dBm) Current frequency (Hz) Chromatic Dispersion and DGD counter on the OTN side</td>
</tr>
<tr>
<td>Debug and Alarms</td>
<td>PRBS – generator and checker Loopback – hostif and networkif PM Counters</td>
</tr>
<tr>
<td>Management and Automation</td>
<td>ZTP, Netconf/Openconfig, Telemetry</td>
</tr>
<tr>
<td>Supported CFP2 vendors</td>
<td>Lumentum, Fujitsu, Acacia</td>
</tr>
</tbody>
</table>
# A Disaggregated Packet Optical Solution Offers Significant Value

![Disaggregated Packet Optical Solution Diagram]

<table>
<thead>
<tr>
<th>REQUIREMENTS</th>
<th>FEATURES/Benefits</th>
</tr>
</thead>
</table>
| Performance and Footprint Optimized | • DSP  
                                 | • Photonic integration                                                           |
| Pluggable                     | • Pay-as-you-grow (PAYG) consumption model; defers capex when required  
                                 | • Allows service agility                                                         |
| Flexible                      | • Configurable operating modes: Modulation, FEC, output power, spectral shaping (Nyquist)  
                                 | • Application and capacity agility: 100G or 200G, metro, LH                      |
| Programmable                  | • Interface, API, Architecture  
                                 | • Standards-based, mature, commercially available hardware and software solutions  
                                 | • Reduces integration time and complexity; avoids proprietary vendor equipment locked-in |
| Interoperable                 | • Conformance to standards assures operators have multi-vendor, multi-source, supply continuity  
                                 | • Competition drives innovation and keeps costs in check                         |
IP Infusion Contributions to TIP

**Building Open and Disaggregated Transport Networks**

- Networking Operating Systems (OOPT - NOS)
- Converged Architectures for Network Disaggregation & Integration (CANDI)
- Control, Information Models and APIs (CIMA)
- Disaggregated Cell Site Gateways (DCSG)
- Disaggregated Open Routers (DOR)
- Physical Simulation Environment (PSE)
- Disaggregated Optical Systems (DOS)
- Disaggregated Open Routers (DOR)

**Roadmap 2021**

- **PHOENIX** (L0/L1) - 400G Optical Transponder
- Full compliance with DCSG specifications (Disaggregated Cell Site Gateway)

**First production-ready NOS for Cassini**

- **CASSINI** (L1/L2)
- (Packet-Optical Transponder)
Summary

- Growing bandwidth demand for new services will be increasingly met by optimized 100G+ WDM platforms.
  - DCI, enterprise services, fixed access, and mobile transport are all underlying drivers for optical transport investment
  - 100G will be the dominant speed by 2020, with 200G and 400G wavelengths ramping up quickly

- Operator driven initiatives to drive the roadmap towards partial and full disaggregation
  - Initiatives such as the OOPT from TIP driven by service providers
  - Move towards open standard interfaces for operational simplicity

- Take advantage of innovations on the photonics and coherent optical transport in a pluggable form factor
  - Modular optics enable Pay-as-you-grow (PAYG) consumption model; defers capex when required
  - Allows service agility
Deploying Cassini in the Real World
Takeaways from the first nationwide deployment
Use Cases

Metro Data Center Interconnect

Backhaul

Long Haul

IP Backbone
Collapsing the Network Layers

Traditional Multi Layer Model

- Routing
- Switching
- Optics

LAN

WAN

Collapsed Model

- Routing
- Switching
- Optics

Layer 3

Layer 2

Layer 1

LAN

WAN

3.2 Tbps
Benefit: Multi-Layer Optimization

In Traditional Networks, it is difficult to make routing decisions taking into account the Optical Topology, and the IP/MPLS plane.

By Collapsing the Layers, there is a single network, that can route based on traditional routing criteria.
New Technology: **Coherent Optics**

**Traditional NRZ Optics**

- 1
- 0
- 0
- 1
- 1

**Evolution**

**Coherent Optics**

- QPSK
- 8-QAM
- 16-QAM

**Single Polarization Signal**

QPSK: 1 Baud = 2 Bits
16QAM: 1 Baud = 4 Bits

**Dual Polarization Signal**

DP-QPSK: 1 Baud = 4 Bits
DP-16QAM: 1 Baud = 8 Bits
Higher Spectral Efficiency

200 Gbps @ DP-16QAM, within 50 Ghz

191.25 THz
...
196.10 THz

19.4 Tbps

Theoretical Capacity

<table>
<thead>
<tr>
<th>Modulación</th>
<th>DP-QPSK</th>
<th>DP-8QAM</th>
<th>DP-16QAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacidad</td>
<td>100 Gbps</td>
<td>200 Gbps</td>
<td>200 Gbps</td>
</tr>
<tr>
<td>Bits/Baud</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Bauds</td>
<td>34.5 GBaud</td>
<td>45 GBaud</td>
<td>34.5 GBaud</td>
</tr>
<tr>
<td>Bits/Hz</td>
<td>2.5</td>
<td>3.5</td>
<td>5.2</td>
</tr>
<tr>
<td>Ancho de Banda</td>
<td>40 Ghz</td>
<td>57 Ghz</td>
<td>38 Ghz</td>
</tr>
</tbody>
</table>

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Real Case: Point-to-Point Dark Fiber

No Amplification

Modulation-format: dp-8-qam
TX-Output-Power: 3.00 dBm
Current PRE FEC BER: 2.623478e-04
Current Input Power: -19.97 dBm
Current OSNR Estimate: 38.50 dB
Current Q-Margin: 3.90 dB
Current Uncorrected Block-count: 0

Modulation-format: dp-8-qam
TX-Output-Power: 3.00 dBm
Current PRE FEC BER: 2.623478e-04
Current Input Power: -19.14 dBm
Current OSNR Estimate: 38.50 dB
Current Q-Margin: 3.90 dB
Current Uncorrected Block-count: 0

~90 Km / 23 dB

Dark Fiber, no electronics at all
Real Case: Amplified / Multiplexed
Larger Distances

Modulation-format : dp-8-qam
TX-Output-Power : -3.00 dBm
TX-Laser-freq : 193500000 MHz
Current PRE FEC BER : 1.083477e-03
Current Input Power : -11.81 dBm
Current OSNR Estimate : 31.20 dB
Current Q-Margin : 2.80 dB
Current Uncorrected Block-count : 0

Modulation-format : dp-8-qam
TX-Output-Power : -5.00 dBm
TX-Laser-freq : 193500000 MHz
Current PRE FEC BER : 7.966043e-03
Current Input Power : -10.89 dBm
Current OSNR Estimate : 34.40 dB
Current Q-Margin : 2.90 dB
Current Uncorrected Block-count : 0
Real Case: Productive DWDM Network
Network with Amplifiers and MUX/DMUX, shared with prod traffic

Tests on the Telefónica Network were published in a Paper.

Disaggregated Packet Transponder field demonstration exercising multi-format transmission with multi-vendor, open packet optical network elements

Geraldine Franza, N. Rajji Nagesh, Wataru Ishida, D. Yashikar Sato, Shalabh Kudhyavelsh, and Victor Lopez

Abstract: We demonstrate a field trial of 100G/200Gbps allochotous wavelength transmission and management onto a deployed live system (Telefónica del Perú nationwide field network) with disaggregated packet transponder, adopting multi-vendor CFP2-ACO / CFP2-DCO transceivers.

1. Introduction

Open networking and disaggregation are common trends in the industry. Open Compute Project (OCP) [1] and Telecom Infra Project (TIP) [2] are the two main activities that are impacting the industry. While OCP started with more focus on the data center, TIP is focused on Telecom environments. Within the Open Optical & Packet Transport (OOPT) working group in TIP the Disaggregated Optical Systems subgroup has defined the network elements to achieve the goal of disaggregation offering wider choice to operators. The definition of technology-focused white books such as Vajper and Cassini enables the creation of a vendor neutral abstraction framework such as Open Transport Abstraction Interface (TAl) [1], where, plugable manufacturers can test and integrate their solutions. Building on this foundation is the MOS layer which provides a uniform control, management interface for end-end service management.

Coherent optics for metro and long haul transmission traditionally have been integrated almost exclusively into proprietary network equipment manufacturers (NEM) systems, from LD/31 optical transport systems, to 12GE/10GE Ethernet switch/routers. As the trend continues towards commercially available packet optical network systems, customers have an increasing number of options, enabling a flexible and cost-effective scalable network.

3. Field Trial Results

Fig. 3 shows the summary of transmission test results for each configuration. RFC 2544 test was passed for 100G DP-QPSK 1250km transmission and 200G DP-16QAM 640km transmission.
Long Haul Links, with no regeneration!
It is a matter of Signal Quality (OSNR)

You can Amplify the signal (let's say, indefinitely)

but, each amplifiers introduce Noise, that degrades the signal quality.
Deploying the Largest Cassini Network
Building the Next-Generation Mundo Pacifico Network, in Chile

Mundo Pacifico activates HyperNET, the first disaggregated optical network in Latin America, using #Cassini from Telecom Infra Project.
The components

- DCO PIU
- DC PSU
- CASSINI

ipinfusion™

ACACIA

LUMENTUM

Edge-core
NETWORKS

whitestack™
A new way to build a Network
Changing the paradigm
Challenges!
Overcoming the obstacles!

Change of Paradigm
- Operators think in terms of layers!
- They are realizing the benefits of collapsing layers.

Technical Challenges
- Learning Optics (Power, BER, OSNR, ..)
- Optical Links auto recovery & monitoring

Logistics (during COVID times) - Initial delays
- Component Factories were closed!
- Airports were closed!
- Mobility Constraints!
Summary

- **It works**
  - Open Networking, works in a production network!
  - Disaggregated Optics, works in a production network!

- **It is more efficient**
  - Energy
  - Space
  - Operationally

- **Not a Box, but an Strategy**
  Upcoming boxes:
  - Galileo
  - Phoenix
Gracias!
Q&A

Please use Question/Chat Box.
Thank you for joining us today