

GE
Grid Solutions

Lentronics

Providing mission critical communications, protection, control, monitoring, and diagnostics of utility and industrial grids maximizing reliability, efficiency, security, and operational excellence



City of Independence P&L

NG JPAX MPLS-TP Packet Transport Equipment

May 6th, 2022

GE Proposal – QC20114B-BN (Issue 3) (OP22031335150)



imagination at work

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Edgard Sammour
Senior Sales Manager

May 6th, 2022.

**Mr. John George,
City of Independence, Power & Light,
17221 East 23rd. Street South, P.O. Box 1019,
Independence, MO. 64051.**

Tel: 816-325-6281

Mobile: 816-564-4912

Dear Mr. George,

GE Grid Solutions, LLC is pleased to re-issue Proposal **QC20114B-BN (Issue 3)** providing pricing for two new NG (Next Generation) JPAX MPLS-TP Packet Transport nodes for City of Independence Power & Light, to build a new 10G Packet Transport network between the existing NOC site and the Fire Station site.

Issue 3 – Re-issued the Proposal without change to all the equipment, except the Price Validity is changed and extended for thirty days. And the Prices in Pricing Summary page now include the decimal cents.

The GE product portfolio gives critical infrastructure network operators confidence to upgrade and/or migrate their communications network to the NG (Next Generation) technology through a cost-effective, risk-free migration path. GE delivers field hardened platforms that guarantee support for mission-critical applications while providing a future-proof transition to a new technology network.

In this proposal offer, GE illustrates the feasibility and practicality of future migration of existing IP&L's system replacement using GE's new generation system, JunglePAX 'Hybrid' MPLS-TP/SONET platform (JPAX). The proposed GE 'Hybrid' JPAX supports both MPLS-TP and SONET on the same network element and transports them over the same optical WAN link. The system supports packet-over-packet for Ethernet traffic, TDM-over-packet (TDMoP), and TDM-over-SONET (TDMoS). The added JPAX design feature, 'Hybrid Platform' allows TDM-based relaying applications circuits to operate on the TDM-over-SONET (TDMoS) preserving the SONET performance if needed, by reducing the propagation latency.

The design of JPAX MPLS-TP product allows IP&L to implement their existing network migration in a couple of different approaches.

- With separate fibers, the new MPLS-TP (JPAX) network will be built to overlay the existing network, one ring at a time during the migration process. The existing traffic can then



progressively be transferred from existing to new network with no or minimum interruption.

- Another approach will be deploying JPAX's (proprietary) 'Evolution' module. JPAX Evolution module will be used to provide interfaces between the existing JMUX network and the new JPAX, while one JPAX node is progressively added to build the new MPLS-TP platform. The interfaces between the two systems allow SCL to pass traffic between the existing JMUX and JPAX while migrate the system to the new platform, one node and one ring at a time. The product compatibility design between the two systems also provides flexibility for SCL to maintain the existing circuits while taking steps to migrate the system to the new platform at minimum cost and time constraint.

The JPAX Hybrid MPLS-TP/SONET platform is designed for utilities with critical utility communications in mind. GE's JPAX offers a truly converged solution with security and dependability for all applications whether they are critical Tele-protection circuits or for less-time-sensitive business IT needs. Security and Dependability ensure data will be delivered and received on time when an actual data packet is sent, and at the same time, data will not be falsely received when no data was sent. Both are key performance requirements to ensure utility communications are always operating reliably. JPAX equipment is

- Purpose-Built for Superior Performance
- Single solution converging and simplifying operations
- Ruggedized and Modular Design Lowering Total Cost of Ownership

In this Proposal, GE proposed basic MPLS-TP nodes for single type of network and capacity requirements. The JPAX network can easily be enhanced and expanded. For IT main office application, 10G WAN network with basic LAN drop ports will be more appropriate and for OT office application, additional DS-0 drop circuit interfaces, like C37.94 and RS-232 protection circuit cards, will be added. For other remote and lesser capacity networks, the cost-saving 1G WAN network can be substituted. The 1G JPAX node can easily be expanded to 10G WAN by merely adding 10G SFP laser modules to create the 10G WAN network. Each CORE Unit comes ready with two 10G ports and four 1G ports, all un-equipped.

The JPAX node comes (included) with its eMS (Embedded Manager) plus Telenium Network Manager (Gold option) licenses for the JPAX NMS.

Beside the above basic Offer for basic network application, additional interface cards are readily available for:

- T1/E1 application.
- High density card, Quad channel per card, for the Protection C37.94 circuit.
- Data card with RS-232/G703 interface.
- Protection – Direct relay and Direct Transfer Trip iDS0 cards.
- CBUS card (proprietary) for allowing the JPAX to connect directly to existing JMux SONET TDM DS-0 interface cards, like 4-wire VF card, 2-wire FXS/FXO cards.

With the added built-in feature of JPAX MPLS-TP equipment, JPAX's WAN port(s) can be user-configured to support its 'Hybrid' functionality where certain selected 'Traffic' (for mission critical circuits) can be user-configure to transport over the same MPLS-TP WAN network, using the JPAX SONET/SDH Layer, instead of the standard JPAX MPLS Layer. The resultant benefit will be lower propagation latency for Mission Critical circuits. Refer attached Product Brochure for details.



As an optional application, JPAX comes with its new Evolution Module application that can be added to the new JPAX MPLS-TP network arrangement to allow the already invested existing JMux SONET/SDH network equipment to use the JPAX MPLS-TP network to extend the 'reach' of the existing JMux SONET/SDH networks.

In addition, design of the new JPAX iDS0 drop interface cards, like C37.94 and RS-232 Data, will inter-operate seamlessly with the legacy (TDM) JMux C37.94 (Nx 64F) Data card and RS-232 LS Data card.

Refer Description of Offered Equipment in section 4 for more detail illustration on the application of JPAX equipment.

GE would like to ensure the customer that it is taking appropriate and reasonable measures to mitigate the impact of Covid-19 pandemic on its operations, applying governmental and World Health Organization's recommendations or directions. However, the evolution of the Covid-19 pandemic and its concrete impact on the execution of projects cannot be fully anticipated. This proposal takes into account the Covid-19 situation and the measures that are being applied by GE as of the date of this proposal but does not account for any potential evolution of Covid-19 pandemic and the adverse impacts it could have on GE's ability to perform obligations set in the proposal. In the event of any evolution of Covid-19 situation before the expiry date or acceptance by the customer of this proposal, GE reserves the right to notify the customer of such impact and modify its proposal accordingly and reasonably. During contract performance, in the event of any delays or other adverse impact due to evolution of Covid-19 pandemic, GE reserves the right for an equitable adjustment of the schedule and prices herein to offset the effects of Covid-19 pandemic evolution.

We appreciate this opportunity to present GE Grid Solutions, LLC solution, and look forward to serving your tele-protection communication needs now and in the future. Please feel free to contact either of the undersigned should you have any questions or require additional information.

Sincerely,

Edgard Sammour,
Regional Sales Manager,
GE Renewable Energy,
170 Science Parkway
Rochester, NY 14620-4251
Phone: 972-535-5769 Mobile: 972-626-1325
e-mail: Edgard.Sammour@ge.com

Bob Ng,
Proposal Specialist,
GE Grid Solutions
8525 Baxter Place, Suite 100,
Burnaby, B.C. V5A 4V7. Canada
Tel: 604-421-8627
Email: bob.ng@ge.com



PROPRIETARY STATEMENT

The information contained in this Proposal is proprietary information of **GE Grid Solutions, LLC**, and is submitted on the understanding that it shall not be used or disclosed for any purpose other than the evaluation of this proposal by **City of Independence** and that **City of Independence** shall use its best efforts to prevent disclosure of the aforesaid information to persons outside. The term "best efforts" shall be construed as being equivalent to **City of Independence's** normal efforts to prevent inadvertent disclosure of its own proprietary information.

Information is subject to change, since **GE Grid Solutions, LLC** reserves the right, without notice, to make changes in equipment design or components as progress in engineering or manufacturing methods may warrant.



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SECTION 1

PRICING SUMMARY / TERMS & CONDITIONS



GE Grid Solutions

To: City of Independence P&L (INDMO)
17221 East 23rd. Street South
Independence, MO. 64051.

Attn: Mr. John George

6-May-2022

8525 Baxter Place, Suite 100,
Burnaby, B.C. V5A 4V7 Canada
Tel: 604.421.8700 Fax: 604.421.8707

Proposal:

QC20114B-BN

ISSUE 3

Page 1 of 2

In response to your request we take pleasure in proposing:

Terms of Payment: Net 30 Days		DELIVERY: 12 Weeks ARO	FOB: Point of Shipping Freight - Prepaid & Charged	
Item	Qty	Description	Unit Price	Total Price
		90000 Lentronics JunglePAX Converged Platform	<u>USD</u>	<u>USD</u>
		<u>JPAX MPLS-TP EQUIPMENT</u>		
1.00	2	New MPLS-TP JPAX Converged Nodes , equipped with: - Protected CORE Modules (Licensed 2x 10G WAN ports). - Protected Power Modules (48/130-VDC). - Ethernet Unit with Quad 10/100/1000BT, RJ-45 Ports. - Ethernet Unit with Quad SFP Ports. - PROTECTION - IEEE C37.94, 1-port, Form-C e/w SFP SMF - PROTECTION - DIRECT RELAY (232/G703), 1-port, Form-C - JPAX eMS license & Telenium Network Manager (GOLD) License. per attached detail equipment list in section 3.	\$30,640.40	\$61,280.80
2.00	6	90550-02/G JPAX - 8x5 Annual Extended GOLD Support Services <i>(Note: Qty. 6 for the total of three years)</i>	\$300.00	\$1,800.00
3.00	1 Lot	Recommended Operation & Maintenance SPARES per attached detail equipment list in section 3.	\$6,300.00	\$6,300.00
		<u>On-Site Field Support Services</u>		
1.00	1 Lot	On-Site Technical Support Services (with one Field Service Engineer) includes- - 1 days on-site commissioning - 2 days JPAX Training (6 students) - 2 days Travel, T&L Expenses (food, lodging, auto).	\$12,125.00	\$12,125.00
		<u>NOTE:</u> The impacts of Coronavirus and the hyper-inflation cannot be reasonably determined at this time. This Proposal does not account for any potential adverse impacts of such on GE's performance of obligations. In the event of any delays and impacts, GE reserve the right for an equitable adjustment of the schedule and prices herein to offset the effect of Coronavirus and hyper-inflation delays.		
BASEBID EQUIPMENT & SERVICES STOTAL =				\$81,505.80
Federal Sales Tax		<input type="checkbox"/> Included	State & Municipal Sales Tax	
		<input checked="" type="checkbox"/> Excluded		
			<input type="checkbox"/> Included	
			<input checked="" type="checkbox"/> Excluded	

This offer expires within 30 days of the date set forth above unless purchaser's acceptance is received by GE Grid Solutions prior to that date.

Purchaser's Order No.: _____

Special instructions: _____
Shipping point: _____
Shipping date: _____
Completion date: _____

This offer is subject to the terms on the face hereof and in the proposal enclosed with this offer. Please read all terms on the front and back of all pages.

GE Grid Solutions

Purchaser's Acceptance

Destination : ☐ Include ☒ Exclude freight charges

By: Edgard Summon

By: _____

Title: Regional Sales Manager

Title: _____

Date: 6-May-22

Date: _____

The warranty period ("Warranty Period") is 24 Months from the date of shipment

Signature: _____

Signature: _____

All of us ... Always with unyielding integrity ...



GE GRID SOLUTIONS, LLC
STANDARD TERMS AND CONDITIONS OF SALE

For

this Proposal QC20114-BN

Is pursuant to

<https://store.gegridsolutions.com/termEM104-Grid.pdf>



Terms and Conditions for Sale of Products and Services Software License Addendum (Rev 3)

THIS ADDENDUM INCORPORATES BY REFERENCE THE TERMS AND CONDITIONS TO WHICH THEY ARE ATTACHED AND INCLUDES THE FOLLOWING ADDITIONAL PROVISIONS CONTAINED HEREIN. IN THE EVENT OF ANY CONFLICT BETWEEN THIS ADDENDUM AND THE TERMS AND CONDITIONS, THE ADDENDUM SHALL TAKE PRECEDENCE.

1. Definitions. Unless otherwise agreed to by Licensor, the following terms shall mean:

"Derivative Works" includes but is not limited to (a) any work based upon one or more pre-existing works, such as a revision, enhancement, modification, translation, abridgement, condensation, expansion, extension or any other form in which such pre-existing works may be recast, transformed, or adapted, and that, if prepared without the authorization of the owner of the copyright to such pre-existing works, would constitute a copyright infringement, and/or (b) any compilation that incorporates such pre-existing works. For Software, Documentation, and Third Party Software (as defined below), Derivative Works also includes any and all corrections, bug fixes, and updates to the Software, Documentation, Third Party Software, and Derivative Works, but does not include any Licensee or Licensee-funded third party developments, provided such developments only make "calls" of the Software, Third Party Software or Derivative Works thereof or "object requests" that reference or cause execution of the base Software, Third Party Software, and/or Derivative Works thereof.

"Documentation" means all material, including all printed material and on-line or electronic documentation (excluding training materials), referencing the Software and/or Third-Party Software provided hereunder.

"Licensee" means the Buyer as that term is defined in the Terms and Conditions.

"Licensor" means the Seller as that term is defined in the Terms and Conditions.

"Software" means Licensor's proprietary computer software and software security devices provided by Licensor under this License.

"Terms and Conditions" means Licensor's Terms and Conditions for Sale of Products and/or Services to which this License is attached.

"Third-Party Software" means any proprietary computer software owned by a third party that Licensor may provide to Licensee hereunder.

2. License Grant.

2.1 Subject to the terms of this License, Licensor hereby grants to Licensee a non-transferrable and nonexclusive license to use Software and Documentation, including upgraded, modified or enhanced versions provided by Licensor, and to use Third-Party Software, all for Licensee's internal business purposes only.

2.2 Licensee has no right to (i) lease, rent, transfer, distribute, sublicense, timeshare, or allow third parties to access Software, Documentation, or Third-Party Software, nor assign any rights hereunder to a third party without Licensor's prior, written agreement; (ii) disassemble, decompile, reverse engineer, or otherwise attempt to reconstruct or discover the source code of the Software or Third-Party Software; (iii) pledge Software or Third-Party Software as collateral or otherwise, or encumber such Software or Third-Party Software with any lien or security interest; or (iv) remove any product identification, copyright, trademark, or other notice from Software, Documentation or Third-Party Software. If Licensee believes that it is entitled to reverse engineer Software as a matter of local law (e.g., the Council Directive of May 14, 1991, of the Council of the European Communities, as amended), Licensee agrees that it shall first request technical information from Licensor. Licensee shall use any technical information delivered by Licensor only for purposes of ensuring "interoperability" and compatibility and shall treat such technical information as Proprietary Information (defined below). Any reverse engineering of Software shall void any warranties or indemnification obligations of Licensor and shall automatically release Licensor from any obligation to provide support services under this or any separate agreement.



2.3 Certain software Licensor provides to Licensee may contain Third-Party Software, including but not limited to "open source" software. Use of Third-Party Software and its source code may be governed by separate copyright notices and license provisions, which may be found or identified in Documentation or on the media delivered with Software and which are incorporated by reference into this License. Licensee shall not modify or combine Software and/or any Third-Party Software in any manner that could cause, or could be interpreted or asserted to cause, Software or any modifications thereto to become subject to the terms of any license applicable to Third Party Software. All Third-Party Software provided hereunder is bundled with Products and licensed for use with Products only.

2.4 Unless otherwise agreed to by Licensor or specified in an Exhibit attached hereto, Licensee shall only have the right to install and use a single copy of Software and Third-Party Software on a single computer workstation for use by a single user.

2.5 Licensee may make one (1) copy of Software, Documentation, and Third-Party Software for backup purposes only. Licensee must reproduce and include all proprietary rights and copyright notices on any backup copies. Except as authorized under this License, no copies of Software, Documentation, or Third-Party Software may be made by Licensee or any third party; provided, however, Licensee may print on-line Software documentation for its own internal use, provided the maximum number of copies may not exceed the number of users licensed hereunder.

3. Support Services; Upgrades.

This License does not obligate Licensor to provide maintenance and support on any Software or Third-Party Software licensed hereunder. Support services are available under separate agreement. If Software is an upgrade of a previous version (provided such upgrade was obtained under a separate support services agreement with Licensor or a Licensor authorized distributor), Licensee may use the upgraded Software only in accordance with this License.

4. Verification.

During the term of this License and for 3 years thereafter, Licensor may upon reasonable notice require that an independent audit of the use of Software and Third-Party Software be conducted during Licensee's normal business hours. Upon such notice, Licensee shall provide Licensor's independent auditor site access and the right to inspect relevant portions of Licensee's computer system on which Software and Third-Party Software resides. Licensee agrees to pay promptly: (a) all underpaid license fees and (b) if the underpayment is more than 5% of the license fees paid before audit, all audit costs and expenses.

5. Term and Termination.

5.1 Software, Documentation, and Third-Party Software shall be considered accepted by Licensee upon receipt.

5.2 This License is effective until terminated. Licensor may terminate this License immediately if Licensee fails to comply with any of the terms and conditions herein. The license for any Software or Third Party Software provided with leased equipment shall terminate concurrently with termination of the lease. Upon termination, Licensee shall (a) cease using Software, Documentation, and Third-Party Software and (b) certify to Licensor within one (1) month of the termination that Licensee has destroyed or returned to Licensor Software, Documentation, and Third-Party Software, and all copies thereof.

6. Ownership.

6.1 All Software, Documentation, and Third-Party Software are licensed and not sold. Licensee agrees that Licensor and its suppliers own all proprietary rights, including, but not limited to any patent, copyright, trade secret, trademark, and other proprietary rights, in and to Software, Documentation, and Third-Party Software, including any Derivative Works (defined above) thereof regardless of the source of development, including but not limited to cases where Licensee engages a third party to perform such development and any corrections, bug fixes, and updates to such Software, Documentation, Third-Party Software, or Derivative Works.

6.2 Therefore, to the extent that any Derivative Works of Licensor's proprietary Software or of Third Party Software supplied by Licensor is developed, Licensee hereby (a) agrees that the intellectual property rights to such Derivative Works are automatically vested in Licensor (or its affiliates, in Licensor's sole discretion) or in the owner of Third Party Software, as applicable, and may be used by Licensor (or the owner of any Third Party Software Derivative Works) without limitation and without any obligation to Licensee on behalf of Licensor and/or such other relevant owner; (b) irrevocably transfers and assigns to Licensor all intellectual property rights, moral rights, title, and interest throughout the world in and to any such Derivative Works, including, but not limited to, all rights in and to any inventions and designs embodied in such Derivative Works or its associated technology; (c) agrees and forever waives any right to



assert any claim contrary to (a) and (b) in this Article 6.2; and (d) agrees to take all steps necessary to fulfil the requirements as set forth in this Article 6.2 for any such Derivative Works whether developed by Licensee or by any third party under Licensee's direction. If by operation of law such rights are not automatically transferred and assigned as provided above, Licensee shall execute and deliver such instruments and take such other action as may be requested by Licensor to perfect and protect Licensor's (or Third Party Software owner's) rights in any Derivative Works and to carry out the assignments effected by this Article 6.

6.3 Notwithstanding the foregoing, Licensor grants Licensee a "right to use" license to any Software or Third Party Software Derivative Works for internal business purposes only under the same terms and conditions that apply to Software, Documentation, or Third Party Software under Article 2 herein.

6.4 For the purposes of Article 6, the term "Licensor" shall mean Licensor, its affiliates, and their successors or assigns.

7. Limited Warranties.

7.1 Licensor warrants for Licensee's benefit alone that under normal use the media in which Software is embedded shall be free from defects in material and workmanship, for the period defined in ES 104 Rev 4 Article 5. ("Warranty Period").

7.2 Licensor warrants, for Licensee's benefit alone, that during the Warranty Period, Software will perform substantially in accordance with its Documentation. If, during the Warranty Period, an Error occurs (where "Error" is defined as a problem caused by an incorrect operation of the unmodified computer code in Software or an incorrect statement or diagram in Documentation that produces incorrect results), Licensor will use commercially reasonable efforts to correct such Error, provided Licensee furnishes Licensor with the following: (a) written notice of the warranty claim, including a description of the failure to perform in accordance with Documentation and a specific description of the operating conditions (including the specific software/hardware configuration) under which the failure occurred, and (b) to the extent feasible, a representative sample of inputs for repeating and analysing the failure. If Licensor is unable, after commercially reasonable efforts, to correct the Error, Licensee's sole remedy shall be termination of this License and a refund of the license fees allocable to the specific nonconforming Software that have been paid by Licensee to Licensor hereunder.

7.3 Article 7 provides the exclusive remedies for all claims based on failure of or defect in Software and Documentation, whether the failure or defect arises before, during, or after the applicable Warranty Period and whether a claim, however described, is based on contract, warranty, indemnity, tort/extracontractual liability (including negligence), strict liability, or otherwise. The warranties provided in Article 7 are exclusive and are in lieu of all other warranties, conditions, and guarantees whether written, oral, implied, or statutory. NO IMPLIED STATUTORY WARRANTY OR CONDITION OF MERCHANTABILITY, SATISFACTORY QUALITY, OR FITNESS FOR A PARTICULAR PURPOSE APPLIES. WITHOUT LIMITING THE FOREGOING, LICENSOR DOES NOT WARRANT THAT THE SOFTWARE OR DOCUMENTATION (OR LICENSEE'S USE THEREOF) WILL BE FREE FROM ALL ERRORS OR ITS USE WILL BE UNINTERRUPTED.

7.4 Any remedial steps taken by Licensor hereunder shall not extend the applicable Warranty Period.

7.5 Except as expressly authorized by Licensor in writing, all Third-Party Software shall carry only the warranties provided by the owners thereof and Licensor gives no warranties for such Third-Party Software.

8. Proprietary Information; Equitable Relief.

8.1 All information concerning or embedded in Software (including but not limited to source code and training materials), Documentation, and Third-Party Software is confidential and shall be considered Licensor's (or its suppliers') proprietary information ("Proprietary Information") whether or not the information is marked as Proprietary Information. Proprietary Information includes commercially valuable, substantial trade secrets, the design and development of which reflect the effort of skilled development experts and investment of considerable amounts of time and money.

8.2 Licensee acknowledges: (a) any use of Software, Documentation, or Third-Party Software in a manner inconsistent with this License or (b) any other misuse of Proprietary Information of Licensor (or its suppliers), will cause immediate irreparable harm to Licensor (or its suppliers) for which there is no adequate remedy at law. Licensee agrees that Licensor (or its suppliers) shall be entitled to immediate and permanent injunctive relief from a court of competent jurisdiction in the event of any such misuse or threatened misuse by Licensee. The parties agree and stipulate that Licensor shall be entitled to such injunctive relief without posting of a bond or other security; provided, however, that if the posting of a bond is a prerequisite to obtaining injunctive relief, then a bond in an amount equivalent to U.S. \$1,000



shall be sufficient. Nothing contained herein shall limit Licensor's right to any remedies at law, including the recovery of damages from Licensee for breach of this License.

8.3 The confidentiality obligations set forth in the Terms and Conditions with respect to items of Confidential Information shall expire, with respect to Software, and Documentation, five years after termination of the Contract



SECTION 2

ORDER, DELIVERY & PRICING INFO



Order, Delivery & Pricing Information

A. Quote Addendum

The following terms shall apply to the referenced quote and where they differ, shall take precedence over those included in GE Grid Solutions, LLC latest revision Form EM104 Terms and Conditions for Sales of Products and Services:

1. WARRANTY

Unless otherwise stated in the Contract, the warranty period for Lentronics' products shall be two (2) years from the date of shipment from Seller's facility or Shipping Point.

2. PAYMENT TERMS

Terms of payment shall provide for (i) one hundred (100%) per cent cash for each shipment, payment due net thirty (30) days upon presentation by the Seller of its invoices and (ii) evidence of readiness to ship to the Buyer or at a paying agency in Toronto, Canada acceptable to the Seller.

NOTE:

Buyer's Purchase Order must identify the above terms as they are deviations from GE Grid Solutions, LLC's standard latest revision Form EM104 which shall govern the purchase.

B. Ordering & Delivery Inquiries

The purchase order may be issued referencing the proposal number or a copy of the proposal can be attached to the order. Purchase Order shall be made out to:

GE Grid Solutions, LLC
4200 Wildwood Parkway, Bldg. 2018
Atlanta, GA. 30339. USA

Please direct all orders and delivery inquiries to the following Customer Service Representative:

GE Multilin,
Attention: Order/Sales Support
Tel: 905-927-7070
Toll Free: 1-800-547-8629 (for US/Can only)
e-mail: sales.gridsolutionsIC@ge.com
Fax: 905-927-5455



Invoice Remit to Address is:

Check: **GE Grid Solutions, LLC**
PO Box 743504,
Atlanta, GA 30374-3504,
USA.

Wire: **GE Grid Solutions, LLC**
Bank of America,
Swift Code: BOFAUS3N,
ABA #: 026009593.
Account #: 4451055312.
ACH Route No: 111000012

Contact Name **AR Department Enquiries**
Tel: 905-858-5265.
Fax.: 905 927-5098

Federal Tax ID No. 47-3196244

C. Pricing

- 1) Prices stated in this proposal are at NET and are **valid for 30 days** from the date of this letter.
- 2) Unless stated otherwise all prices are in US Dollars, exclusive of sales, federal, and local taxes.
- 3) The enclosed Terms and Conditions apply to any purchase resulting from this proposal.
- 4) Prices do not include any charges for warehousing of equipment. If warehousing is required, GE Grid Solutions, LLC reserves the right to invoice on a monthly basis for the storage of any equipment.
- 5) Prices stated in this proposal **do not** include transportation. If a collect account is not provided at the time of Purchase Order placement, transportation will be selected by GE using the least cost common carrier and billed back to the customer at the time of invoice, using our standard INCO term, FCA-Seller's Plant.
- 6) This proposal was prepared without the benefit of a site survey; therefore, certain office conditions and/or site environments may exist which require materials external to the system quoted and may not be included in this proposal.



SECTION 3

DETAIL EQUIPMENT LIST

Customer: **City of Independence P&L (INDMO)**
 Project: **QC20114B-BN**
 Date: **May 6, 2022**
 Expires: **June 5, 2022**
 Config: **90000 JunglePAX System**
 version 4.27 - RELEASED

ISSUE 3

Column 1

Column 2

ITEM NO.	PRODUCT DESCRIPTION	LOOSE PART #	ENG. CODE	UNIT PRICE	NOC Node		Fire Station Node	
					QTY	EXTENDED PRICE	QTY	EXTENDED PRICE
#1.0	COMMON JUNGLEPAX EQUIPMENT							
	<u>SHELF</u>							
	COMMON JPAX SHELF (2RU)	90001-01	S1	4320.00	1		1	
	<u>POWER</u>							
	POWER CONVERTER 48/130VDC	90110-01	W1	1050.00	2		2	
	<u>BLANKS</u>							
	ACCESS BLANK (1 SLOT), Ventilated	90099-05		49.50	12		12	
#2.0	JPAX WAN INTERFACES							
	<u>MPLS-TP CORE</u>							
	MPLS-TP CORE, Unlicensed, 2x 10G, 4x 1G capable	90010-01	C1	5250.00	2		2	
	<u>NODE LICENSING (Base eMS)</u>							
	# 10G WAN Port License (Max 4 per node)	90010/10G	/10G	1000.00	2		2	
	<u>10G SFP+</u>							
	SFP+, 10G, SR, LC, SMF, 1310nm, 10km	90010/A	/A	455.00	2		2	
#3.0	JPAX ACCESS INTERFACES							
	<u>ETHERNET</u>							
	ETHERNET (4G), 4x 10/100/1000BT, RJ-45	90201-01	E0.2	1650.00	1		1	
	ETHERNET (4G), 4x 1 GE, SFP	90200-01	E0.1	1650.00	1		1	
	1000B-LX TRANSCEIVER, 1310nm IR-1, 11dB, SMF, LC, 10k	90200/AA		123.20	2		2	
	<u>IDS0</u>							
	PROTECTION - IEEE C37.94 SFP, 1-port, Form-C	90360-01	P2	1050.00	1		1	
	C37.94 SFP SMF	90360/AA		70.00	1		1	
	PROTECTION - DIRECT RELAY (232/G703), 1-port, Form-C	90350-01	P3	1050.00	1		1	
#4.0	CABLING KIT / ACCESSORIES							
	Cable, Serial, USB	90900-01		15.00	1		1	
#5.0	SOFTWARE							
	Embedded Manager - BASIC eMS, NETWORK, per node RTU	90000-02		1250.00	1		1	
	Network Manager - Primary NMS Service (GOLD), Per node, 1 client s	90000-50/G		2000.00	1		1	
#6.0	PROFESSIONAL SERVICES							
	<u>FACTORY SERVICES</u>							
	SYSTEM WIRE & TEST LABOUR - Basic 4hrs/Node	90000-STA1		900.00	1		1	
	ORDER ENGINEERING - FACTORY (JPAX)	OE-JPAX		335.00	1		1	
	<u>SUPPORT SERVICES</u>							
	BASIC ANNUAL SUPPORT	90520-01		N/C	1		1	
TOTAL EQUIPMENT PRICING IN USD						\$30,640.40		\$30,640.40

Customer: **City of Independence P&L (INDMO)**
 Project: **QC20114B-BN**
 Date: **May 6, 2022**
 Expires: **June 5, 2022**
 Config: **90000 JunglePAX System**
 version 4.27 - RELEASED

ISSUE 3

Column 3

ITEM NO.	PRODUCT DESCRIPTION	LOOSE PART #	ENG. CODE	UNIT PRICE	SPARES		TOTAL PRICE	
					QTY	EXTENDED PRICE	QTY	EXTENDED PRICE
#1.0	COMMON JUNGLEPAX EQUIPMENT							
	<u>SHELF</u>							
	COMMON JPAX SHELF (2RU)	90001-01	S1	4320.00			2	
	<u>POWER</u>							
	POWER CONVERTER 48/130VDC	90110-01	W1	1050.00	1	1050.00	5	
	<u>BLANKS</u>							
	ACCESS BLANK (1 SLOT), Ventilated	90099-05		49.50			24	
#2.0	JPAX WAN INTERFACES							
	<u>MPLS-TP CORE</u>							
	MPLS-TP CORE, Unlicensed, 2x 10G, 4x 1G capable	90010-01	C1	5250.00	1	5250.00	5	
	<u>NODE LICENSING (Base eMS)</u>							
	# 10G WAN Port License (Max 4 per node)	90010/10G	/10G	1000.00			4	
	<u>10G SFP+</u>							
	SFP+, 10G, SR, LC, SMF, 1310nm, 10km	90010/A	/A	455.00			4	
#3.0	JPAX ACCESS INTERFACES							
	<u>ETHERNET</u>							
	ETHERNET (4G), 4x 10/100/1000BT, RJ-45	90201-01	E0.2	1650.00			2	
	ETHERNET (4G), 4x 1 GE, SFP	90200-01	E0.1	1650.00			2	
	1000B-LX TRANSCEIVER, 1310nm IR-1, 11dB, SMF, LC, 10k	90200/AA		123.20			4	
	<u>IDS0</u>							
	PROTECTION - IEEE C37.94 SFP, 1-port, Form-C	90360-01	P2	1050.00			2	
	C37.94 SFP SMF	90360/AA		70.00			2	
	PROTECTION - DIRECT RELAY (232/G703), 1-port, Form-C	90350-01	P3	1050.00			2	
#4.0	CABLING KIT / ACCESSORIES							
	Cable, Serial, USB	90900-01		15.00			2	
#5.0	SOFTWARE							
	Embedded Manager - BASIC eMS, NETWORK, per node RTU	90000-02		1250.00			2	
	Network Manager - Primary NMS Service (GOLD), Per node, 1 client s	90000-50/G		2000.00			2	
#6.0	PROFESSIONAL SERVICES							
	<u>FACTORY SERVICES</u>							
	SYSTEM WIRE & TEST LABOUR - Basic 4hrs/Node	90000-STA1		900.00			2	
	ORDER ENGINEERING - FACTORY (JPAX)	OE-JPAX		335.00			2	
	<u>SUPPORT SERVICES</u>							
	BASIC ANNUAL SUPPORT	90520-01		N/C			2	
TOTAL EQUIPMENT PRICING IN USD						\$6,300.00		\$67,580.80



SECTION 4

DESCRIPTION OF OFFER

JPAX MPLS-TP PACKET TRANSPORT EQUIPMENT



1. Executive Summary

General Electric's Industrial Communications division is pleased to offer City of Independence, Power & Light (IP&L) our GE Lenronics JunglePAX (JPAX) packet-based transport multiplexer as a NextGen solution to modernize IP&L's OT network. The JPAX was purpose-built using GE Lenronics' decades of experience in the OT transport domain so that it addresses today and tomorrow's utility OT applications using modern technology.

The proposed JPAX platform offers reliable and secure 10G/1G data transport for legacy as well as modern utility OT applications. It carries OT data over a packetized MPLS-TP network to enable highly flexible and resilient topologies that resemble what OT engineers are used to with SONET. Furthermore, the JPAX distinguishes itself in the OT transport industry with its additional feature, the '**Hybrid**' transport mode, whereby tele-protection circuits can be user-configured to provision it to operate in a native TDM mode over the same MPLS-TP fiber backbone to meet stringent latency and determinism requirements.

To make operating and maintaining the system easier, JPAX offers a simplified user interface that allows operators and field technicians to quickly master its operation in lesser time. JPAX's NMS full integration with MegaSys Technologies' Telenium NMS platform constitutes a significant investment protection to IP&L due to the platform being able to manage IP&L's other networks if deemed beneficial.

GE has also implemented backward compatibility solutions to allow the JPAX to interop with the existing SONET JMUX network to enable a paced migration to JPAX with minimum interruption to operation and services.

We harvested our decades of experience building reliable OT transport equipment in the ground-up design and manufacturing of Lenronics JPAX platform. It is built as a rugged, fan-less substation-hardened system which consumes less power and that withstands extreme operating conditions.

Finally, from a lifecycle perspective, the JPAX platform has exited its introduction phase and is now well into its high adoption and growth phase with several high-profile utility deployments completed, including in Texas, Florida and California. This is the platform that GE Industrial Communications will focus investment in so that we effectively support our utility customers' OT networks into the future.

We appreciate the opportunity to have supported IP&L's current SONET JMUX network for the past 20 years, and we look forward to continuing our investment and partnership with you in the future with our JPAX platform.



2. Features and Benefits of the GE Lentrionics JPAX Solution

A. Purpose-Built for Utilities

General Electric, a world leader in the design and deployment of advanced power utility grid technologies and solutions brings a wide breadth of knowledge to our design and implementation of utility communications network solutions. GE JPAX solution is purpose-built for utility private optical operational networks (OT), with best-in-class performance for operational services such as traditional tele-protection and SCADA, as well as modern protocols such as IEC 61850 GOOSE, Sampled Values, Synchro-phasors, all while being designed with NERC-CIP compliance in mind.

B. Purpose-Built for Utilities

JPAX enables a 10-Gbps or 1-Gbps backbone with connection-oriented Layer 2.5 packet transport technology based on MPLS-TP. The JPAX Network Element complies with the MPLS-TP specifications and can be deployed as part of a network that has pre-existing packet transport equipment, allowing IP/MPLS to run on top. TP shares the label-based forward classes, but without the associated complexity of requiring Layer 3 routing tables or control protocols, and without the dependency of any management or control plane.

C. Native TDM Transport

In addition to the standard MPLS-TP packet transport mode, JPAX offers the optional feature capability of a native TDM transport mode. This **'Hybrid'** mode enables tele-protection VTs (in SONET) to be transported over Time Division Multiplexing mechanism offering a SONET-like determinism and performance to ensure minimum jitter, and a 0.5 msec network latency for critical tele-protection applications when transported over JPAX SONET layer, (instead of 2.1 msec over JPAX MPLS layer), giving an end-to-end service latency within 4 msec, excluding the fiber span propagation delay.

D. Backward Compatible with JMUX

The JPAX platform supports various backward compatible modes of operation with GE customer's existing JMUX networks to enable a smoother and gradual network upgrade without the need to forklift. The additional special (proprietary) **'Evolution'** module is a network module that plugs into an existing JMUX node to interconnect a newly inserted JPAX node within the existing JMUX SONET network. The Evolution module enables Ethernet as well as VT/TDM traffic to flow back and forth between the JMUX and JPAX networks as an intermediate step while the existing (TDM) network is slowly being migrated to the new packet transport JPAX platform. Moreover, other interoper capabilities including CBUS links between the JPAX and JMUX to connect sites where legacy automation equipment isn't ready to attach directly onto the newer transport technology.

E. Fast Protection Switching

JPAX implements an optimized version of MPLS-TP to provide improved determinism for secure and dependable packet transport. The inclusion of fully redundant custom hardware offers 1+1 protection for fast line protection switching which can recover the network from failed fiber links or network components in less than 5 msec (typically 3 msec for VPWS (Virtual Private Wire Service) protection relay traffic. For VPLS (Virtual Private LAN Service) traffic, the hardware offers 1:1 protection scheme with a line protection switching time of 16 msec for failed fiber links.



F. Synchronous Ethernet for Jitter Control

Layer 1 clock signaling is extended across the entire JPAX MPLS-TP infrastructure utilizing built-in Synchronous Ethernet (SyncE) and IEEE 1588 capabilities. SyncE is fundamental to carrying latency sensitive TDM traffic over a packet network. Hardware additions within the JPAX to control jitter in both working and protect paths are essential, not optional. The JPAX solution enables control within 30 microseconds per node and less than 4 milliseconds for TDM services edge to edge. Precision timing is offered with less than 1 microsecond of accuracy, and it will require the addition of an optional card, JPAX Sync-IN (Timing) Card, connected to Analog or TTL signal and frequency from an external GPS Time Source Clock.

G. Wide Range of Applications

The JPAX, with its wide range of (64K and sub-rate) access interface units, can transport legacy as well as modern tele-protection protocols, in addition to serial, IP, voice and video traffic.

H. Flexible Network Architectures

The JPAX can be deployed in several network topologies – linear networks, ring networks, mesh, and multiple ring networks. With its multiple WAN ports Core Unit, the same JPAX node can be user-configured and designed to provide **multi-tier (layer) networks** with 10G and 1G bandwidths. It can enable point to point, point to multipoint, as well as multipoint to multipoint topologies to meet both OT and IT application needs.

I. Flexible Bandwidth Utilization

JPAX supports TDM pseudowires such as CESoPSN (circuit emulation over packet switched network) and SAToP (structure agnostic TDM over packet) modes. They enable the flexibility of carrying data in TDM circuits over MPLS-TP to emulate SONET transport. L2VPN (Layer-2 Virtual Private Network) and VPLS (Virtual Private LAN Service) instances can be created over the JPAX infrastructure to enable point-to-point and point-to-multipoint connections respectively.

J. Comprehensive OAM

Full OAM (Operations, Administration and Maintenance) support for both underlying Infrastructure and service-based Performance and Availability Management is at the core of the JPAX architecture. With SONET-like OAM transported in-band, GE ensure that OAM traffic, with the same fate as data payloads, to quickly detect and recover from network path failures within 5 msec. In addition to supporting point to multipoint label switched paths, MPLS-TP offers Tx & Rx association to ensure symmetry is maintained which is essential for applications that can be sensitive to asymmetrical delays.

K. Integration with the MegaSys Telenium NMS

The JPAX Network Management System (Element and Network) provides network visibility, information collection, real-time event responses, logging, and provisioning capabilities from the optical level up to the 64K tributary units at every node, minimizing maintenance time and expenses.

JPAX is fully integrated with the Telenium NMS system which has been licensed to GE by MegaSys Computer Technologies to converge multiple platforms onto one pane of glass, including SONET/SDH, MPLS-TP, Hybrid, and Industrial Switch platforms. Telenium provides full FCAPS (Fault, Configuration, Administration, Performance and Security) support for GE equipment with complete JPAX system monitoring, configuring and edge-to-edge provisioning of all tunnels and services via NETCONF. It also



allows the monitoring of SONET/SDH/T1/E1 multiplexer alarms, performance, and activity logs via SNMPv3. Furthermore, it provides a high-availability solution that allows operators to use all systems concurrently, and to ensure full connectivity of the underlying networks.

L. Operates in Harsh Environments

The JPAX has been designed for utility applications to meet SWC (Surge Withstand Capability), Fast Transient and RFI (Radio Frequency Specifications), that are applicable to all Power Utilities, and Zone 4 Earthquake. The JPAX is **fan-less** and does not require a forced cooled environment for it to operate properly. Fans in substation environments can be troublesome due to excessive dust. Fan filters require routine maintenance and can become easily clogged which could result in overheating of the equipment. Fans have been ruled out in the latest IEEE specification 1613, "Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations."

JPAX is built with creative passive cooling mechanism, and it operates in temperatures ranging from -20°C to +60°C.

M. Hot-Swappable Components

All modules in a JPAX system are hot swappable. This allows for field-maintenance or network expansion procedures to be implemented with minimum downtime



How the GE Lentronics JPAX Solution Can Support IP&L

The following section illustrates how GE's JPAX solution can meet and exceed the stated IP&L's objectives:

1. Minimize Total Cost of Ownership (TCO)

- a. **Maintenance:** A system with an improved reliability such as the JPAX will contribute to minimizing the total cost of ownership by reducing maintenance and truck rolls.
- b. **Operation:** The MPLS-TP architecture upon which JPAX is built resembles in many ways the circuit-based architecture that SONET offered in the older JMUX platform. This complexity reduction should contribute positively to enabling operators a fast ramp up to learn and operate the platform.
- c. **Technical Support:** GE industrial communications offers complimentary basic technical support to help Utility customers reduce OPEX. Optional 24x7 support contracts could also be purchased for critical operations and response requirements.
- d. **Hardware Warranty:** GE's basic hardware warranty on the JPAX platform spans two years. Optional warranty extension may be purchased at a (reasonable) cost.
- e. **Network Management:** JPAX's full integration with the MegaSys Telenium NMS system makes operation, monitoring and provisioning easier.
- f. **Product Lifecycle:** GE Lentronics' product lifecycle is long and far surpasses traditional Enterprise-grade networking equipment's. This offers an investment protection by not having to swap out networks every 7 years as is typical for enterprise networks. GE showcased our support to this philosophy with the existing JMUX platform's 20+ years of lifespan at IP&L and with no end in sight of sunseting it as a platform (with the exception of certain modules impacted by 3rd party component supply).
- g. **Fiber Monitoring:** Additionally, upon request, GE can offer an optional centralized fiber OTDR system via our partner Ribbon to proactively monitor the underlying fiber infrastructure and significantly reduce the Mean-Time-To-Repair (MTTR) for fiber cuts. Additionally, this system reduces OPEX by minimizing the typical number of truck rolls needed for a system using hand-held OTDR devices.

2. Improve transport capabilities and functionality (throughput, switching time, routing options, network design, protocols, etc.)

Building the JPAX solution over an MPLS-TP architecture offers the flexibility needed to enable various network architectures and topologies to meet legacy and new application needs. JPAX's ring switching time is 3 msec for VPWS traffic via 1+1 Protection. GE has so far not seen a need from our utility customers to implement IP routing and MPLS/IP on the JPAX platform. This can be a possibility however if the opportunity and demand arise. Finally, the JPAX is designed to transport a host of legacy and modern Tele-protection and automation protocols either directly, or via its CBUS interconnection with an existing JMUX system.



3. Improve reliability

The JPAX platform is built with a host of hardware and software capabilities to minimize downtime and improve recovery time following network outages. The chassis backplane is built with a passive component architecture to reduce failures. The Core cards which interface with the WAN, support a redundant configuration as well as several 1G and 10G WAN connections to offer the flexibility to design a highly resilient network. MPLS-TP's architecture offers several path redundancy mechanisms in order to improve path redundancy. JPAX's hardware design and component quality meet the highest standards of substation-hardened designs in order to improve MTBF and network reliability.

4. Increase overall throughput

Currently, the JPAX platform can operate at 24 Gbps of fully redundant capacity. It can enable 1G or 10G of the Core Card's WAN connections to enable a host of IT and OT applications including throughput-heavy applications such as Synchro-phasors, and Video. The 10-Gbps option ring capacity is more than a 4 to 10x fold increase in throughput over SCL's present existing OC-48 & OC12 (backbone) SONET ring networks, and with a cost-effective 1-Gbps option ring capacity for remote smaller networks. Additional capacity could also be aggregated into underlying DWDM systems if needed.

5. Improve network security

The JPAX is built around a range of cyber-security standards, guidelines, and industry best-practices for critical infrastructure and industrial control systems. Some of the standards include NERC-CIP, NIST SP800-82, NISTIR 7628 and FIPS 140-2.

As a system, the JPAX is architected over a secure communications framework consisting of the following capabilities:

- Digitally signed firmware
- Secure coding practices with Coverity code review
- The use of secure protocols including RADIUS, HTTPS, NETCONF, SNMPv3, and SSH
- Strong authentication, encryption and tunneling algorithms such as SHA-256 and AES 256
- Role-based access control and authorization
- Embedded security policy distribution
- Remote enabling/disabling of LAN and WAN ports
- AES 256-bit encryption of MPLS-TP traffic on WAN ports
- Optional auto-disabling of disconnected operational LAN ports
- Restricted MAC access to LAN ports with optional intrusion detection
- Deployment of security alarms
- Extensive event logging

6. Improve Operation, Administration & Maintenance (OAM) capabilities

As stated earlier, JPAX features a full-fledged OAM support for the underlying transport Infrastructure as well as for service-based Performance and Availability Management. JPAX transport OAM signaling in-band just like with SONET. This ensures that OAM traffic has the same fate as data payloads do and thus enables a quick detection and recovery from network path failures.

7. Provide scalability and flexibility to meet future requirements



The JPAX system scales up to 24 Gbps of Core card, fully redundant, with backbone/WAN speeds of up to 10 Gbps today. Its internal switching capacity is up to 172 Gbps with internal ports considered. The JPAX chassis shelf slots can be mounted with multiple Ethernet cards to enable local access connectivity up to 16x Ethernet ports (with present low port capacity Ethernet card), with various speeds and media types to simplify network design and reducing the cost of deploying a separate Ethernet switch. Higher port capacity Ethernet cards are in the roadmap roll-out and the new high port capacity card, the JPAX can support up to 36x Ethernet ports.

8. Minimize migration disruption

GE designed capabilities in the JPAX and JMUX systems to smoothen the migration process, make it less disruptive to network operations and minimize downtime.

Inserting a JPAX node into an existing JMUX ring can be accomplished using the (GE proprietary) **Evolution** module to allow a paced migration of one node at a time. The evolution module is installed in adjacent JMUX nodes and would extend a connection to the JPAX that's being inserted in between. This connection can enable up to 1G of Ethernet + TDM/VT traffic to flow between the new JPAX and the existing JMUX network.

The JPAX also supports a (proprietary) TDM, CBUS card which provide connectivity into an existing JMUX node to enable legacy protocols to be transported over the new JPAX network. This also enables more flexibility in deployment scheduling especially for sites whose automation equipment isn't ready nor been modernized yet, to connect directly to the JPAX node.

9. Understand the roadmap/pathway to migrate to a new technology

From a lifecycle perspective, the JPAX platform has exited its introduction phase and is now well into its high adoption and growth phase with several high-profile utility deployments completed, including in Texas, Florida and California. JPAX is the platform that GE Industrial Communications will focus its Transport roadmap investment in, so that we effectively support our utility customers' OT networks into the future. The JPAX platform's hardware and software architecture is highly flexible and adaptable. It is designed to be able to accommodate future potential capabilities such as IP Routing, IP/MPLS, as well as additional IP Security capabilities should the need arise. In addition, more 64K drop interface cards, (JPAX iDSO cards) for mounting in the JPAX node assembly chassis are in the roadmap, together with high-capacity access port cards.

10. Simplify Device Portfolio

GE Industrial Communications designed the JPAX solution to be simple and a 'one-box' and form factor. This simplifies the processes of procurement and stocking spares as well as simplifies and streamlines network architecture and deployment. It further optimizes operations by having field maintenance engineers learning about just one box.

System Description (GE JPAX Packet Transport Equipment)

In each of the proposed JPAX nodes, there are two Core Modules (L & R) to provide hardware redundancy and network protection over a Ring Network. All the local drop access interfaces are rear access where each separate type of access interface cards is mounted in one of its sixteen shelf slots. Each JPAX node assembly is equipped with redundant Power Units operating at load-sharing mode. The Power Units are plug-in modules and are mounted from the rear – one on each side of the chassis. The power unit options are 48/130 VDC Power Converter Units and 115/240 VAC Power Converter Unit.



Figure 1

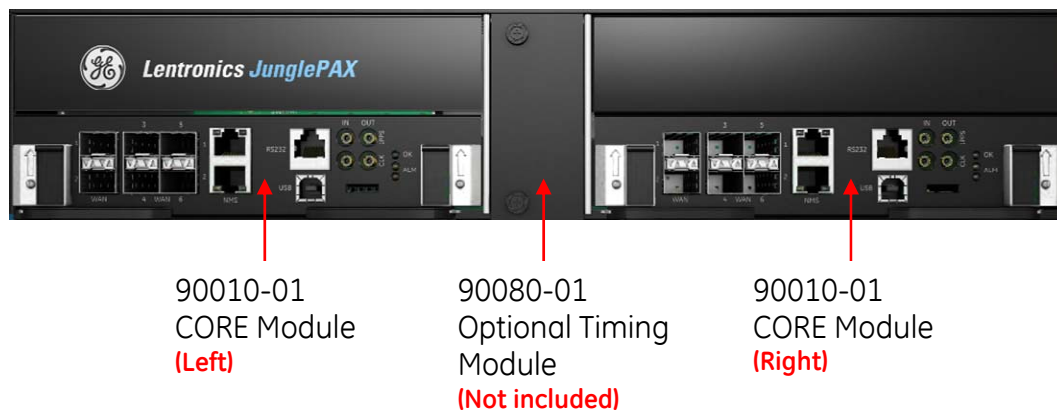


Figure 2 – JPAX Core Modules (Left & Right)

JPAX CORE Unit

The JPAX CORE Unit comes with six WAN ports (per Core Unit), which allow the node to be used to build resilient hybrid MPLS-TP/SONET Ring networks. With its multiple WAN ports, it can support Ring Network, Mesh Network and Hub Network, and the combination. The Core Unit comes with a built-in internal reference clock which can provide network reference timing to all the nodes in the same network.

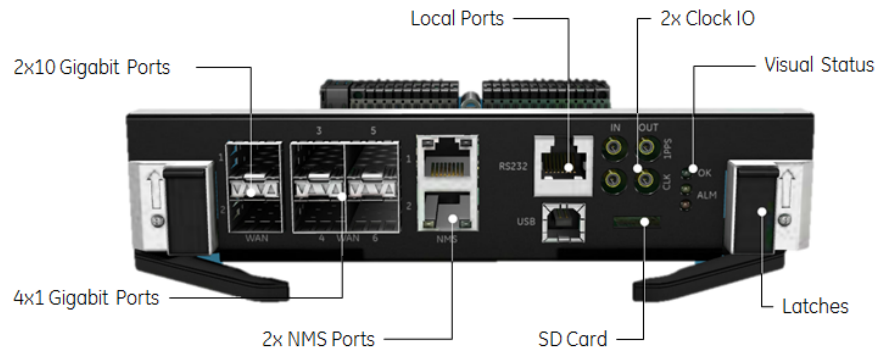


Figure 3

The JPAX node does not come equipped with nor have CPU card or cards. All the configurations for the network circuits are stored in each non-volatile memory (flash) built in individual card, eliminating the need for a separate CPU card.

JPAX is specifically designed to transport mission-critical circuits over a packet transport network with minimum latency and jitter. This is achieved by its Core Unit design such that there will be very low add/drop and pass-thru propagation delay, introduced and added to the circuit. The pass-thru delay is much lower than that typically found in other vendors' IP/MPLS. JPAX design comes with a built-in algorithm table to detect circuit fault in a shorter time, and subsequently provide path switching for the affected circuits. In addition to the above mentioned two (critical) criteria, the JPAX Hybrid MPLS-TP/SONET network will deploy a co-routing application so that all the critical circuits will always be transported in symmetry, i.e. the transmit and receive paths of the same circuit will be transported over the same fiber route, eliminating the presence of any differential delay between the transmit and receive signals of the mission-critical circuits.

In the JPAX Hybrid MPLS-TP/SONET network, all the traffic circuits will be user-configured to propagate over a pre-determined path from the near-end to its far-end locations, and also for the 'Working' and the 'Protection' paths. With the deterministic route in either a simple MPLS-TP/SONET ring network or complex MPLS-TP/SONET multi-rings and mesh networks, the user can easily 'chart' the working and protection paths for each circuit. With that information, it allows the user to calculate the total propagation delay for each circuit and type of traffic. At the same time, it will be easier to carry out troubleshooting when a circuit fault occurs. At the same time, this will reduce or prevent the possibility of a network route, getting towards its maximum bandwidth capacity.



**SHELF REAR SIDE
WITH DROP INTERFACE PLUG-IN CARDS**

Figure 4



In the JPAX assembly chassis, there are sixteen (16x) shelf slots located at the rear of the shelf for drop interface cards. Those (sixteen) slots are for mounting JPAX's various drop interface cards, consisting of:

- **GigE Ethernet cards** with copper 10/100/1000BT RJ-45 Ports (P/N: 90201-01) and SFP (optical) Ports (P/N: 90200-01). Users can equip the JPAX with many same and different types of Ethernet cards (copper and/or fiber) and they can be mounted in the same shelf assembly.
- **Quad-channel RS-232 (sub-rate) data card** (P/N: 90350-02)
- **DTT (Direct Transfer Trip) card** (P/N: 90341-01, -02, -03), providing two transmit and two receive trip circuits. The JPAX DTT unit occupies two rear JPAX shelf slots.
- **C37.94 relay protection card**, comes with a single channel (P/N: 90360-01) or Quad channel per card (P/N: 90360-02).
- **TDM CBUS card** (P/N: 90301-01), a JPAX proprietary interface card that can be added to the JPAX node to connect directly to a JMUX Shelf which can be equipped with any number of JMUX's readily available TDM drop interface cards. The resultant setup will allow the JPAX MPLS-TP network to transport additional TDM DS-0 circuits like 2-Wire FXS/FXO telephone circuits; 4-wire E&M VF circuits.
- **TDM T1/E1 Card** (P/N: 90300-02) for T1 circuits requirement, which could be from an existing T1 Channel Bank circuit assembly and/or T1 circuits for (legacy) Router and Servers. The T1 card is a quad-channel card. Higher density T1 card comes with eight and sixteen (8x or 16x) T1's is also available.
- **G.703 (64K) data card** (P/N: 90366-01)

The addition to the JPAX interface cards, the **Evolution card**, an optional JMUX special and proprietary interface cards, can be added to the existing JMUX node to connect directly an (existing) JMUX SONET network to the JPAX MPLS-TP Network via fiber interface. The Evolution card(s) will be deployed to extend an existing JMUX SONET network over a new JPAX MPLS-TP network seamlessly. With this arrangement, a TDM DS0 circuit in the JMUX SONET network can easily be transported over the Evolution cards, at a collocated site, to the JPAX MPLS-TP network where the same DS0 circuit can be dropped off from a JPAX node, either via a readily available JPAX iDS0 card or via the legacy DS-0 card mounted in an external JMUX shelf after passing thru the CBUS card on JPAX node. Refer to Figure 5.

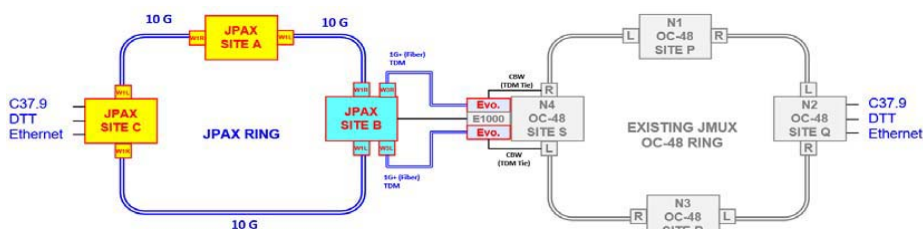


Figure 5A: JMUX/JPAX Interconnection with a Single Tie Site

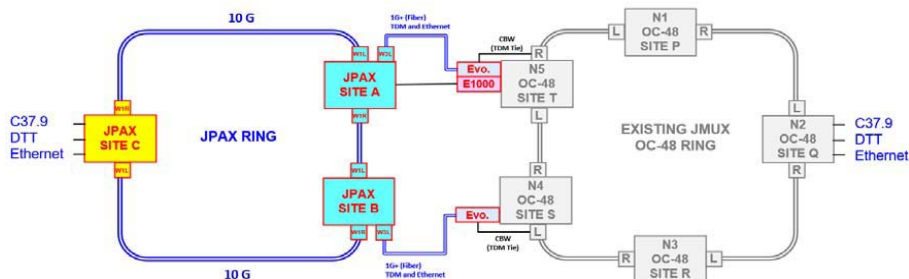


Figure 5B: JMUX/JPAX Interconnection with Dual Tie Sites

JPAX Hybrid Feature/Functionality

JPAX Hybrid MPLS-TP/SONET platform supports a special (proprietary) feature where the (1G and/or 10G Ports) WAN traffic can be user-configurable to transport only JPAX MPLS packet traffic like any standard MPLS-TP network. When required, the same WAN Port's traffic can be user configured to combine the best of Packet and SONET (TDM) in the same fiber. Refer to Figure below.

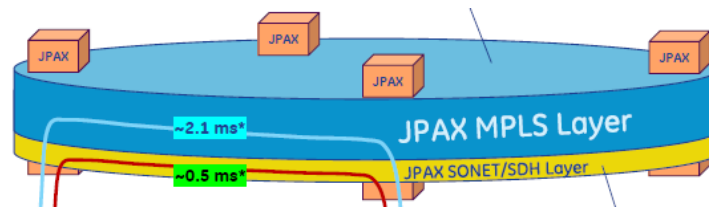


Figure 6

In this application, the JPAX can create JPAX MPLS Layer and JPAX SONET Layer in the WAN traffic propagated over the same fiber. The MPLS Layer will transport the packet traffic while the SONET Layer will be used to transport local SONET (VT-1.5) TDM traffic. With this functionality enabled in the JPAX node, the JPAX's iDSO cards' traffic can be user-configurable to propagate thru the JPAX SONET Layer to the far end, instead of the typical standard approach of using MPLS Packet Layer. As shown in the Figure, the circuit propagation delay can be further reduced from ~2.1 msec. to ~0.5 msec. This lower delay could be critical for mission-critical circuits like the protection relay circuits.

JPAX system is designed to fully support the interconnection with the JMUX system using (proprietary) Evolution Unit.

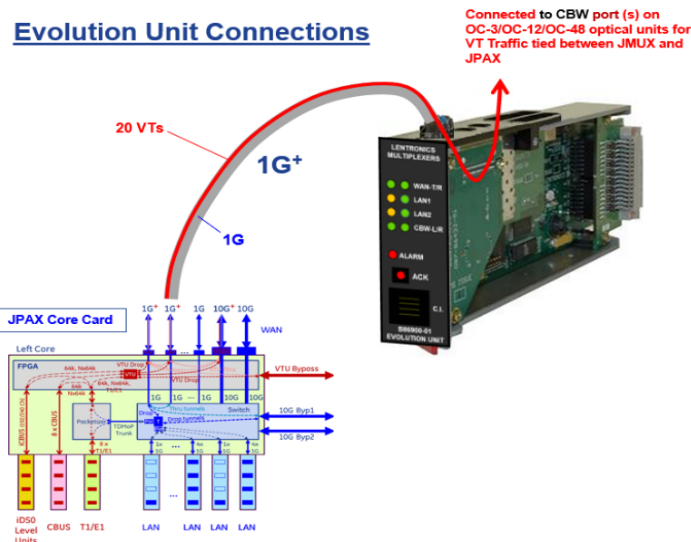


Figure 7

APPLICATION OF JPAX MPLS-TP AND LEGACY JMUX TDM DSO

JPAX node is designed to be able to equip with the JPAX proprietary card, the CBUS card. For project that calls for some legacy TDM drop circuits, like the 2-Wire and/or 4-Wire VF circuits, the CBUS card can be added to JPAX MPLS-TP assembly. Using the standard GE CBUS cable, the drop port (or ports) on CBUS card can easily and seamlessly be extended to a (JPAX) TDM Expansion Shelf where any type of legacy JMux TDM drop circuit card can be equipped in the shelf. For GE JMUX users, the benefit allows the user to continue using their existing installed JMUX DSO cards

For other legacy drop circuit cards, like the 4-Wire VF circuits and Data Nx64 circuits, GE provides its field-proven TDM JMUX cards and mount them in an external JMUX TDM shelf. There is no requirement for the (legacy) DS-0 circuit card(s) to be connected to normal T1 Mux card in a T1 Channel Bank assembly, which in turn will multiplex all the legacy circuit(s) into a T1 bandwidth. In JPAX applications, a unique and proprietary card, the JPAX CBUS card, will be added to the JPAX MPLS-TP node equipment, and subsequently, the (CBUS VT) port will be extended to the legacy TDM shelf equipped with all legacy drop interface cards, like 4-wire VF, 2-wire FXS and FXO cards. Figure 8 below illustrates the connection of the legacy circuit cards, mounted in a JMUX Shelf, to one of the Quad ports on the JPAX CBUS card. The JPAX CBUS card will packetize all the legacy VF circuits and then transport the circuits over the MPLS-TP network using VPWS designation.

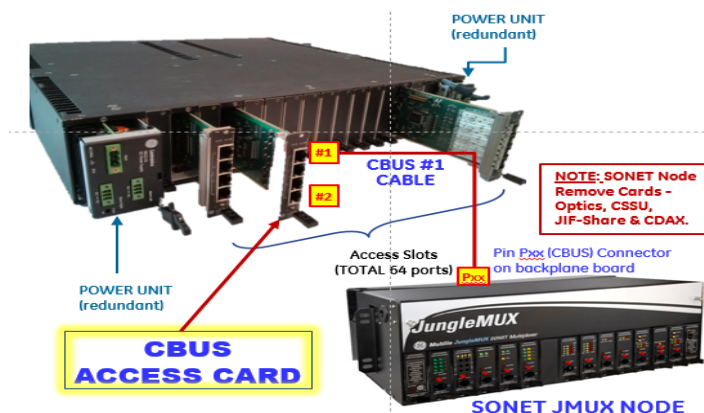


Figure 8

Note: With this differentiating feature (CBUS -VT card) built-in JPAX MPLS-TP equipment design, it is possible for users who already have JMUX TDM equipment at the site, to extend the life of their invested TDM equipment. As a result, all existing station wiring for the station's drop interface equipment can be kept unchanged. This approach will save a lot of time in engineering and man-days to migrate completely from TDM to new MPLS-TP technology, all at one time. With GE JPAX MPLS-TP network, this migration can be done over a longer period of time. At the same time, there will be cost saving on purchasing new legacy TDM cards and Expansion shelves.

QUALITY OF SERVICE

Ensuring the quality of critical applications like those required by PSEG Long Island across the network is a primary driver the reason GE designed and built the JPAX solution from the ground up. Vanilla QoS is offered by all products in this competitive landscape to provide a priority-based solution to classify, schedule, and remark services based on their level of importance. Categorizing applications that are critical and time-sensitive in nature over others is managed within the JPAX product through a unique approach called application defined networking. Application performance and integrity requirements



are uniquely defined within profiles that are applied across the network to ensure they meet those criteria.

TIMING

For this proposal, traditional Headend/Normal nodes are configured. The headend node located at 5HK Hix Prim 1 (R1N1) generates timing for the network. The normal node recovers timing through the fiber optic 'line'. In the absence of a synchronization source (i.e. loss of the headend node where both Left and Right CORE cards are not available), each remote JPAX CORE card supports a built in stratum-3 clock to continue to internally time the remaining network. A synchronization switch occurs at this time, and again with the internal headend node is recovered back into the network.

Outside the scope of this proposal, but when the network is expanded, numerous timing locations can be envisioned and recommended. Two modular timing interface cards would typically be proposed at two strategic JPAX nodes. Locally, the sites should be collocated with external reference clocks. Synchronization derived from the external SSM will be recovered, and a frequency and phase lock performed by the JPAX nodes. The associated SSM quality of each timing signal will too be recovered and used by JPAX to qualify which timing source to time the network.

JPAX networks employ Synchronous Ethernet (SyncE) and ensure all connected JPAX nodes are traceable to the trusted sync source. SyncE is particularly critical to reliably transport TDM services, and all latency sensitive applications.

MANAGEMENT

Each JPAX CORE module is preloaded with 'embedded' management software (p/n 90000-02) called eMS. This embedded solution runs on a dedicated microprocessor core within both redundant CORE modules to perform detailed equipment and system-wide management tasks. A second dedicated microprocessor core is reserved for the JPAX data-plane, ensuring separation and independence of the data v's management systems. eMS also control the configuration of infrastructure and of the services, along with event and alarm storage. Equipment discovery, configuration, and backup are handled along with secure firmware loading, user authentication and authorization, and support for Northbound management interfaces (Netconf, WebUI and CLI (Command Line Interface)).

eMS is NOT an external software solution and so it does not run on a client PC or server. eMS do NOT need the vast array of protocols and interfaces that a traditional EMS (element management solutions) requires. From a user's perspective, the management of a JPAX network is performed through off-the-shelf user web-based applications such as Google Chrome. Web browsers establish a secure connection through any JPAX management port, that acts as a proxy (eMS gateway node) to access a larger JPAX network. JPAX employed eMS is therefore an embedded variant of EMS, providing all equivalent functionality within the JPAX management plane. eMS is duplicated within each JPAX node to ensure high-availability and reliability.

The traditional EMS layer has been effectively removed from the JPAX architecture and replaced by an embedded management system. This approach follows a lean distributed management model instead of a centralized resource-intensive one.

NETWORK MANAGEMENT (NMS MANAGER)

Thru Megasys and GE Lentrionics business relationship, Telenium NMS is used as the NMS Manager for JPAX MPLS-TP networks, providing Operation, Administration and Provisioning functionalities.



The highlights of Telenium NMS Manager functions are described below:

Management Protocol

- JPAX provides the NETCONF standard protocol. MegaSys works with GE to develop the appropriate subdriver to allow communication between the two platforms.
- Security and authentication supported on the JPAX device and this security are compatible with the Telenium system.
- Full FCAPS support is included as outlined below.

Auto-Discovery

- Full auto-discovery of a network element's configuration is made available to the Telenium product. This will allow the Telenium system to accurately represent how the JPAX node is built including card location, card type, firmware release on each card (as applicable), and other typical data such as install date and manufacture date.
- The Telenium system automatically populate its internal network element representation to accurately reflect the location of each card and to be able to present the related data to the customer.

FCAPS

Fault Management

- JPAX provides a mechanism that allows the Telenium system to upload all standing alarms.
- JPAX provides a mechanism to send all new alarms autonomously as permitted by NETCONF to the Telenium system so that polling of the device for alarms is not required.

Configuration Management

- JPAX provides all the necessary interfaces that allow the Telenium system to fully configure (provision) each JPAX network element.
- JPAX provides all traffic details to allow the Telenium system to determine traffic flow through the network element including the ability to determine how traffic connected to external ports is transitioned to the higher speed ports before being transmitted around a ring or linear system. It will also show the reverse, how traffic from a high-speed port is distributed into lower speed ports or, alternatively, redirected or passed through to another high-speed port for forwarding.
- The Telenium system provides the GUI interface to provision equipment including configuring new services over the JPAX network.

Administration Management

- GE and MegaSys jointly work to provide network element backup and restoration capabilities that are automatic between Telenium and the JPAX.
- User accounts and rights on the JPAX will be managed by the Telenium system to ensure that only those accounts that need to exist do in fact exist.

Performance Management



- JPAX provides a mechanism that allows the Telenium system to retrieve performance data from all ports on the JPAX. This PM data will allow for network quality to be determined and provided to the customer.
- PM data will be available on a polled basis as well as on an autonomous basis as long as the autonomous feature for PM data has been enabled on the JPAX and on the Telenium system.
- Historical PM data will also be available to allow the Telenium system to request past PM data for each port.

Security Management

- The Telenium system incorporate the appropriate security controls to ensure that only users with sufficient authorization are permitted to issue certain types of commands.
- The Telenium system record all provisioning commands, whether they success or fail, in the Telenium Audit historical files for post analysis.”

SECURITY

GE's JPAX encryption is performed independently on any of the 6 WAN ports. Encryption is performed with AES 256-bit encryption. All traffic carried on a WAN port would be encrypted (all tunnels, all services, all management data). GE has implemented a patent pending encryption solution that encrypts the entire payload and all headers. GE employs public private keys that can be rolled at a frequency sufficient to eliminate the risk of any brute force attacks. The solution is completely self-contained within each of the core modules, where key generation and distribution is performed and applied optionally across each fiber optic segment. The solution is loosely referenced to 802.1AE. It is more secure since the source and destination MAC address are also encrypted.

Default username and password are assigned to the equipment and will be provided to customers for initial provisioning. Accounts and passwords can be changed using the NMS functionality for user management (roles, groups, profiles). The JPAX supports RADIUS for centralized user authentication.



SECTION 5

EXAMPLE OF APPLICATIONS

OF

JPAX MPLS-TP NETWORK

GE JPAX MPLS-TP's NETWORK APPLICATIONS



GE imagination at work

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2022-03-08

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JunglePAX MPLS-TP APPLICATIONS

EXAMPLE 1 - RING NETWORK TOPOLOGY

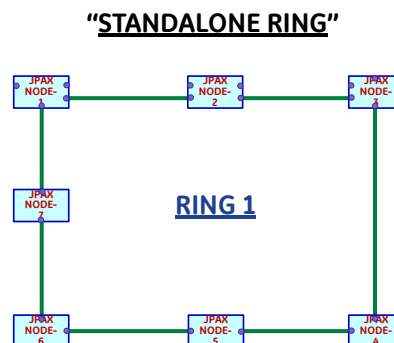


Figure 1

2



imagination at work

JunglePAX MPLS-TP APPLICATIONS

EXAMPLE 2 - TWO RING NETWORK TOPOLOGY

"OVERLAPPING RINGS"

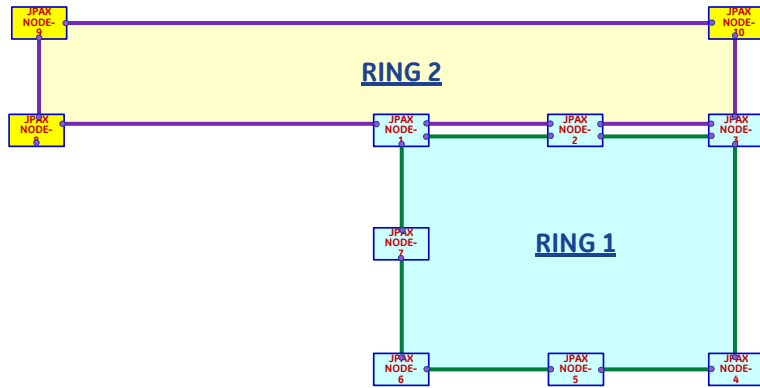


Figure 2

3

JunglePAX MPLS-TP APPLICATIONS

EXAMPLE 3 - SPUR/MESH NETWORK TOPOLOGY

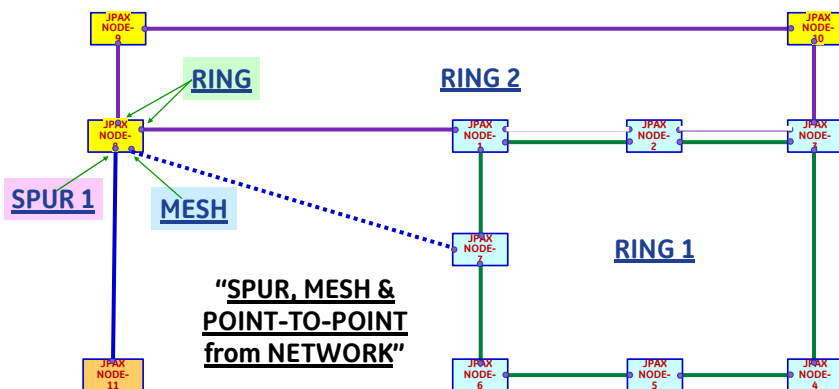
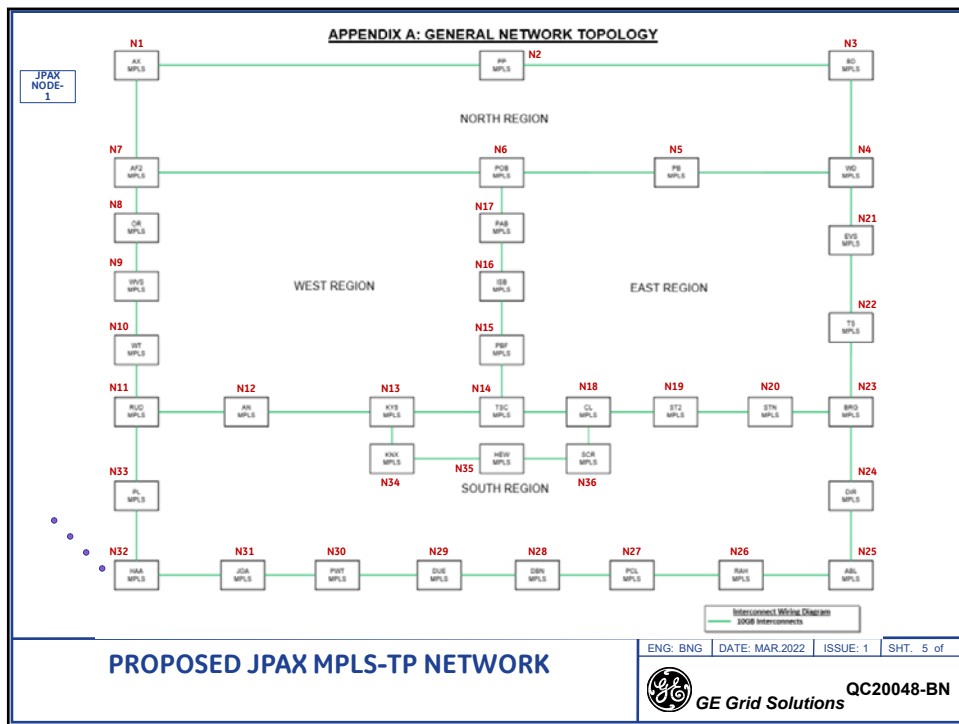
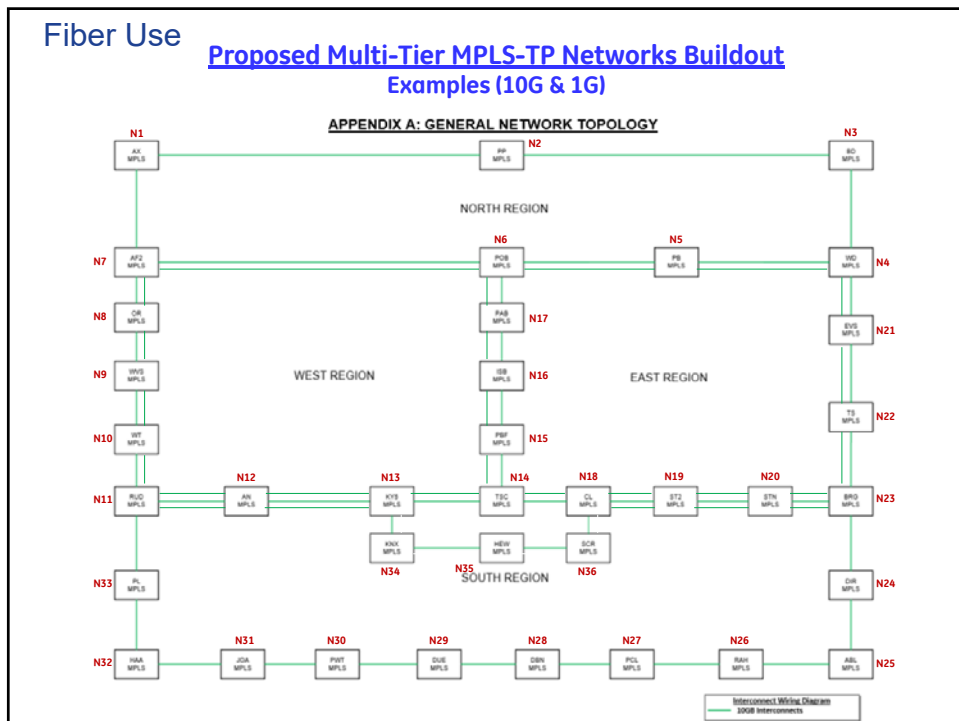


Figure 3

4



5



6

APPLICATION OF JPAX MPLS-TP AS MPLS NETWORK AND HYBRID NETWORK



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JPAX 10G/1G MPLS-TP

19" Rack Mounted MPLS-TP

- Modular design supports multiple types interface cards for application flexibility.
- Supports up to 16 Drop Interface modules in the (2RU) shelf (at the rear).
- CORE Unit Modules are mounted in the front & add/drop Modules are mounted at rear.
- Drop Interfaces – LANs / TDMoP T1/E1 / Data / RS-232 / Protection Relay C37.94 / DTT.
- Hot-swappable
- Redundant power supply Units available with ability to mix input power sources at rear. (AC/DC, High and Low)
- Robust easy to use network management system (eMS & Telenium NMS)



Front View



CORE UNIT (L)
- 2x 10G LINE PORTS
- 4x 1G LINE PORTS
- NMS ACCESS
- TIMING PORT

CORE UNIT (R)
- 2x 10G LINE PORTS
- 4x 1G LINE PORTS
- NMS ACCESS
- TIMING PORT

Rear View



POWER
SUPPLY
UNIT 'L'

DROP INTERFACES
- QUAD RJ-45 PORTS LAN. (10/100/1000)
- QUAD SFP FIBER PORTS (1G)
- QUAD T1/E1 & 8X T1/E1
- QUAD CBUS FOR EXTERNAL TDM DS-O.
- IDSO CARDS - DATA - RS-232 / 422.
- PROTECTION - C37.94.
- PROTECTION - DTT, DIRECT RELAY.

POWER
SUPPLY
UNIT 'R'

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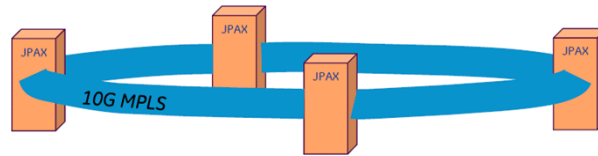
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JPAX MPLS NETWORK

JPAX 10G MPLS RING

* Established over a single pair of fibers.

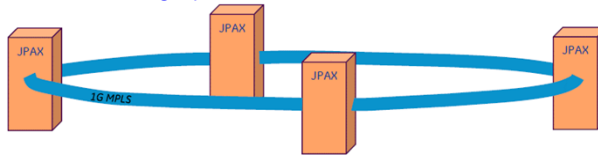
Scenario 1



JPAX 1G MPLS RING

* Established over a single pair of fibers.

Scenario 2



JPAX MPLS-TP NETWORK

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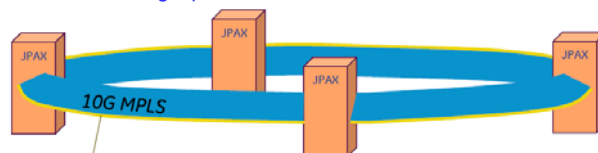
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JPAX HYBRID NETWORK

JPAX 10G HYBRID RING

* Established over a single pair of fibers.

Scenario 3

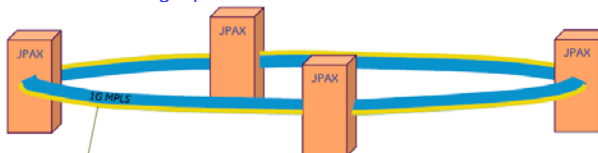


20 VTs or 15 TU-12s

JPAX 1G HYBRID RING

* Established over a single pair of fibers.

Scenario 4



84 VTs or 63 TU-12s

JPAX MPLS-TP (HYBRID) NETWORK

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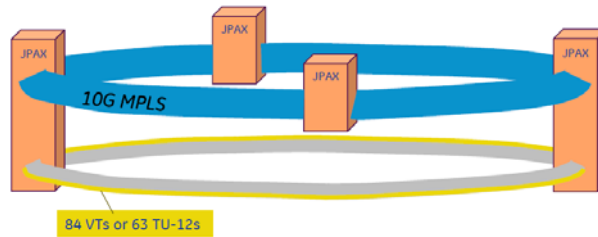
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JPAX HYBRID NETWORK

JPAX 10G & 1G HYBRID RING

* Established over two separate pairs of fibers.

Scenario 5



JPAX MPLS-TP (HYBRID) NETWORK

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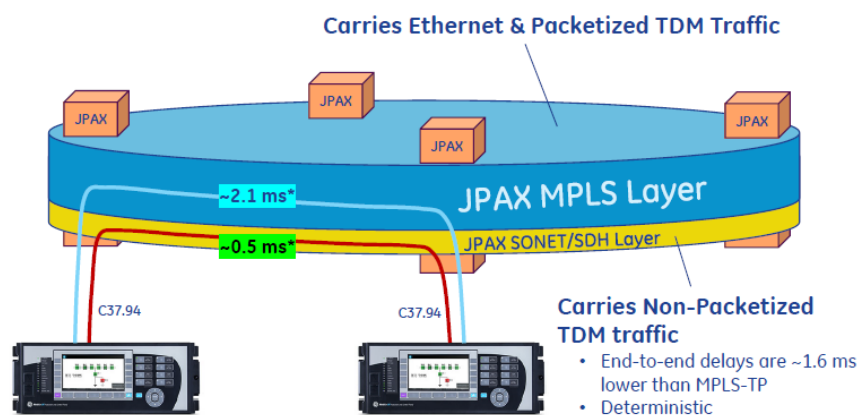
APPLICATION OF JPAX HYBRID NETWORK PROPAGATION DELAY BETWEEN JPAX MPLS LAYER & JPAX SONET/SDH LAYER



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JPAX HYBRID NETWORK



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PROPOSED UPGRADE OF JMUX SONET NETWORK TO JPAX MPLS-TP NETWORKS

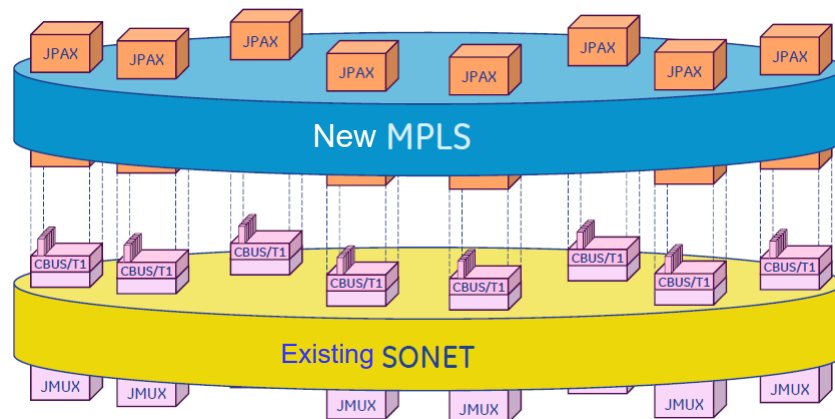


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2022-03-08

15

JPAX NETWORK

Transferring DS0 traffic from JMux to JPAX
(via JPAX CBUS Card)



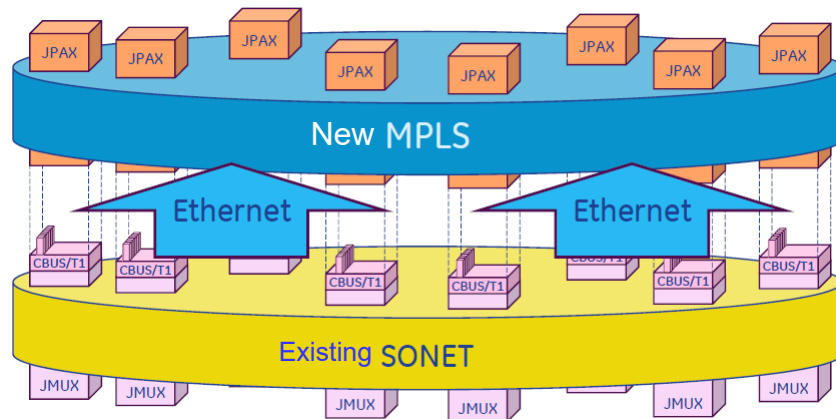
OVER-BUILD JPAX / JMUX NETWORKS

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JPAX NETWORK

Transferring Ethernet traffic from JMux to JPAX
(re-wire to JPAX Ethernet Card)



OVER-BUILD JPAX / JMUX NETWORKS

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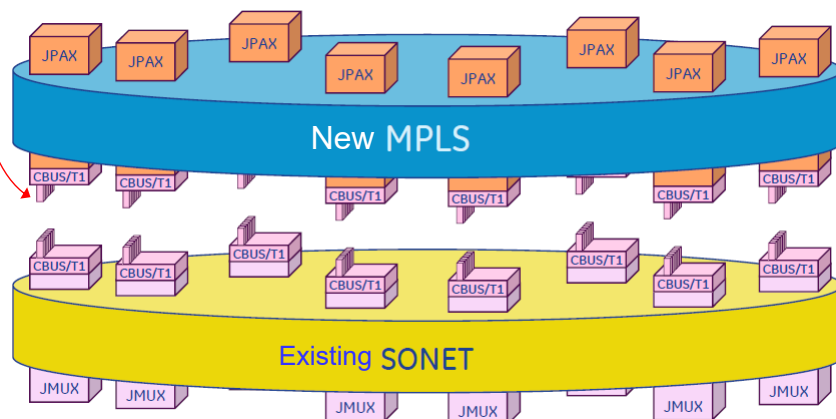
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JPAX NETWORK

Adding new iDS0 cards on JPAX



OVER-BUILD JPAX / JMUX NETWORKS

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PROPOSED EVOLUTION CARD APPLICATION IN SONET & MPLS-TP NETWORKS



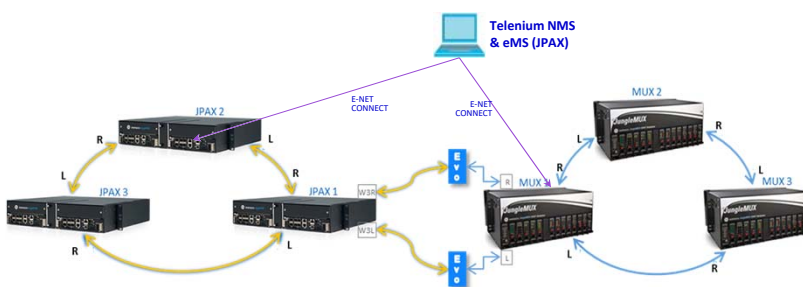
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INTEGRATED NMS FOR MPLS-TP & SONET NETWORKS

MPLS-TP Ring Network

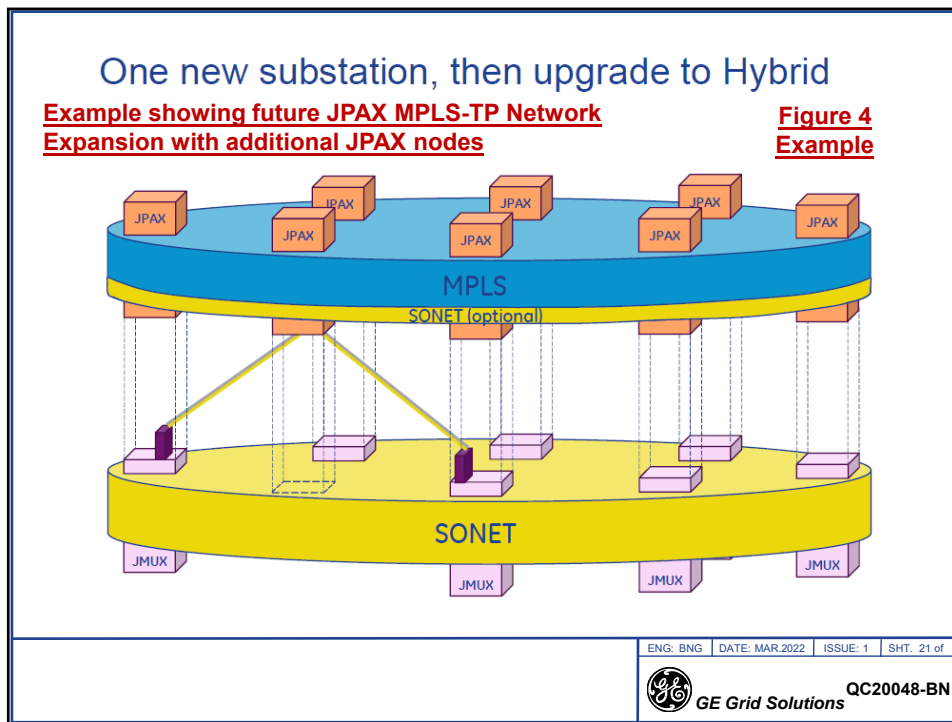
SONET OC-48 Ring Network



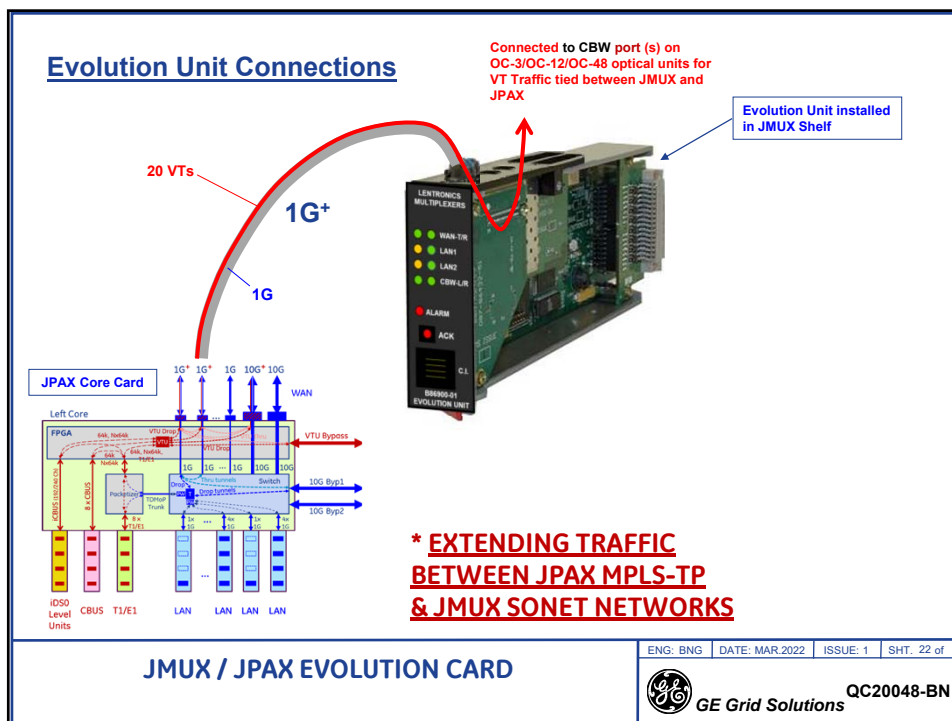
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Lentronics JunglePAX

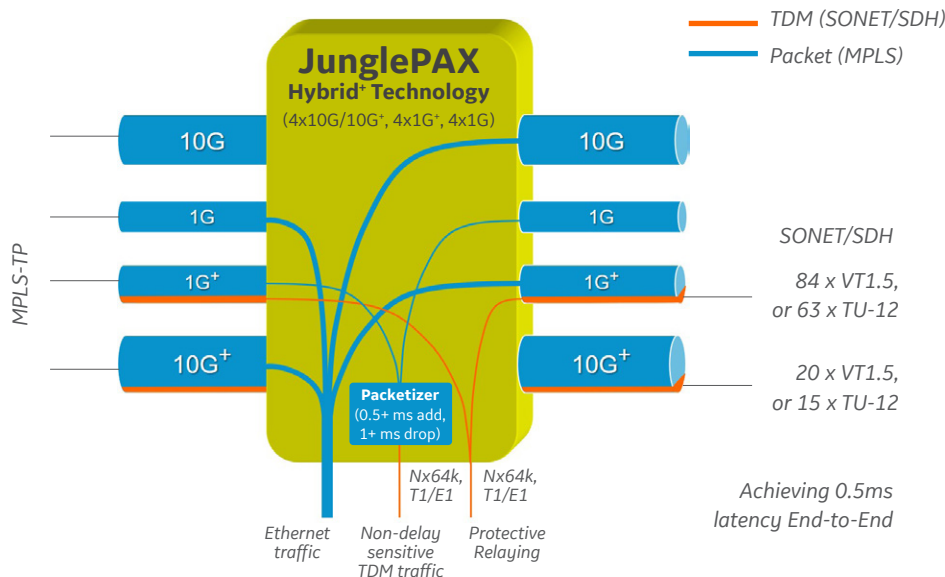
Packet Switched Networking Solution for Teleprotection with Hybrid⁺ Transport Capabilities

GE's Lentronics™ JunglePAX™ is an ideal communications solution specifically designed for utility operations, providing the required security and dependability through layers of redundancy. The platform is based on MPLS-TP (Multi-protocol Label Switching - Transport Profile) technology that maintains deterministic performance through packet based communications to provide utilities with increased efficiency and ease of integration.

The JunglePAX (JPAX) platform employs an optimized version of MPLS-TP, which offers a converged communications platform to reliably add/drop and transport 64 kbps, T1/E1 and Ethernet services across an optical Wide-Area Network (WAN). With a flexible mix of WAN connectivity, access options, and hardware redundancy on critical modules and control functions, the JunglePAX provides utilities a cost-effective, streamlined solution to protect utility assets and improve system reliability.

Hybrid⁺ Transport Mode

To minimize latencies and asymmetric delays for teleprotection services, the JPAX platform implements an innovative Hybrid⁺ technology that allows for optionally carrying TDM services over the SONET/SDH transport layer established alongside the MPLS-TP transport layer (without impacting its capacity) over the same fiber. This innovative transport concept offers the best of both worlds by preserving SONET/SDH performance in a packet-switched network without a need for additional fibers or advanced traffic engineering.



Purpose-built for Teleprotection and Superior Performance

- High speed protection switching within 3ms
- Low end-to-end service latency within 4 ms for MPLS-TP transport layer and within 0.6 ms for SONET/SDH transport layer (excluding propagation delay)
- Designed with layers of redundancy for improved security and dependability
- 'AAA' secured for improved reliability

Single Solution Converging and Simplifying Operations

- Flexible design for deployment across backhaul, aggregation and access networks
- One box solution for mission critical OT and IT networks, capable of connecting multiple and diverse applications
- Integrated and application-driven software simplifies network management
- Network-wide summary and status information dashboard for simplified health and integrity validation

Ruggedized and Modular Design Lowering Total Cost of Ownership

- Industrially hardened with no cooling fans for longer life in harsh environments
- IEEE 1613 and IEC 61850-3 compliant
- Processes 24 Gb/s of traffic across the extended -20°C to + 60°C operating temperature
- Flexible redistribution of service ports
- 10x the capacity of many traditionally designed SONET/SDH networks



Key Benefits

- Supports packet-over-packet, TDM-over-packet (TDMoP), and TDM-over-SONET/SDH (TDMoS) transport over the same fiber
- Improves service quality with a secure and dependable platform that provides reliable communications for utility applications within harsh industrial environments
- Maximizes service uptime using robust hardware to ensure utility-grade performance through layers of redundancy.
- Addresses emerging applications by implementing a flexible and scalable solution to assist with network convergence where traffic and application mix change
- Improves system-wide manageability with integrated and application-driven software that simplifies network management.
- Increases control and promote information assurance with an advanced cyber-security platform that employs defense-in-depth strategies
- Protects the electronics from pests, liquid, dust, and industrial contaminants thanks to patented shelf mechanics with convection cooling chimneys

Customer Challenges

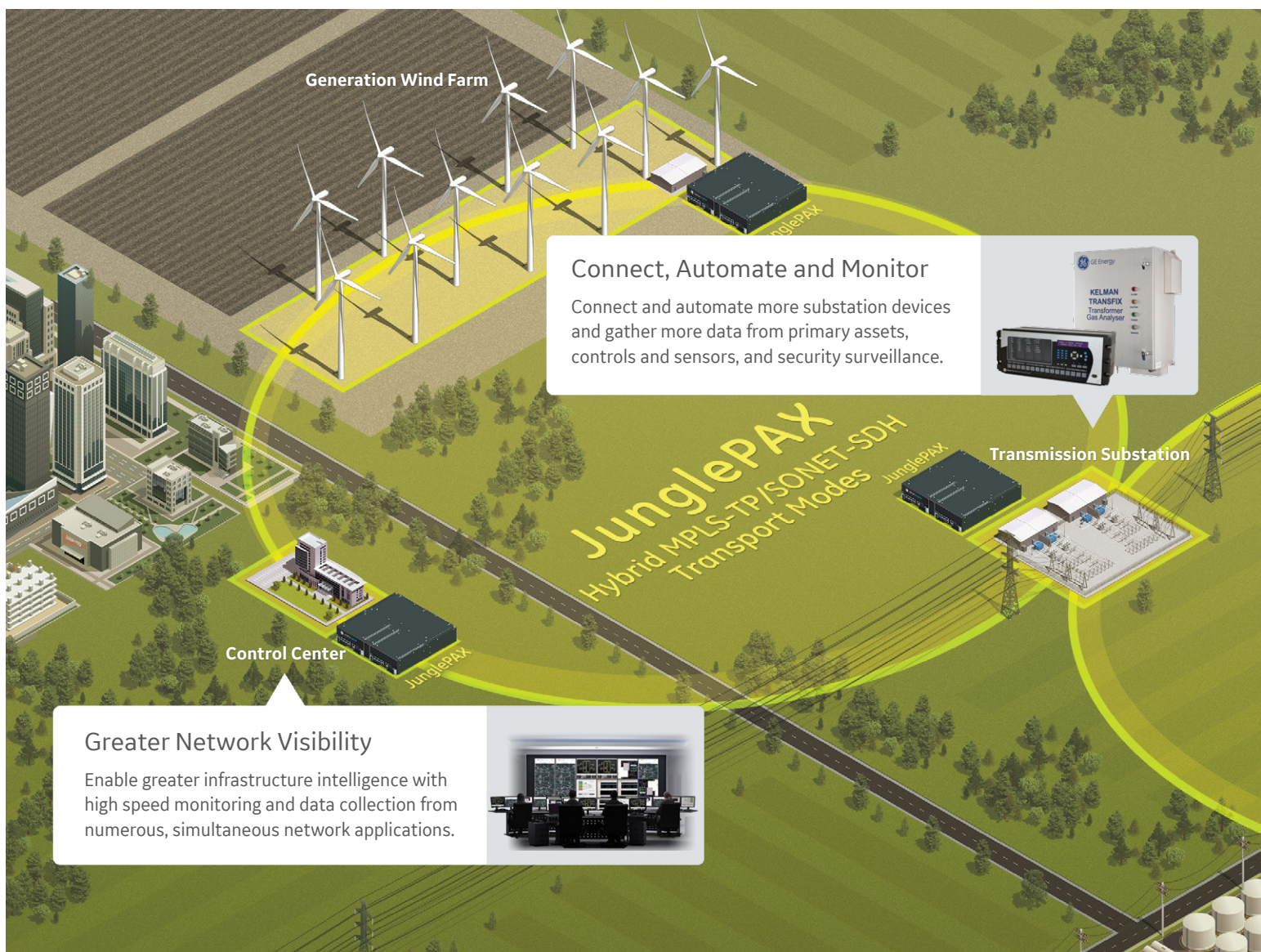
Power Utility Environment

A utilities' communication network is critical to their business operations as they interconnect an array of intelligent electronic devices that enable the reliable and safe delivery of electricity from generation to power consumers. In addition to protecting people and energy assets, utilities are concerned with improving operational efficiency, service quality, maximizing service uptime and mitigating risks associated with cyber-threats.

Power Utility Applications

Critical operational traffic includes applications such as transmission line protection. Essential OT/IT applications are vast and include SCADA, metering, surveillance, maintenance and emergency voice trunking, business service backhaul, remedial actions schemes, real-time fault analysis and intrusion detection.

Lentronics JunglePAX Application Overview

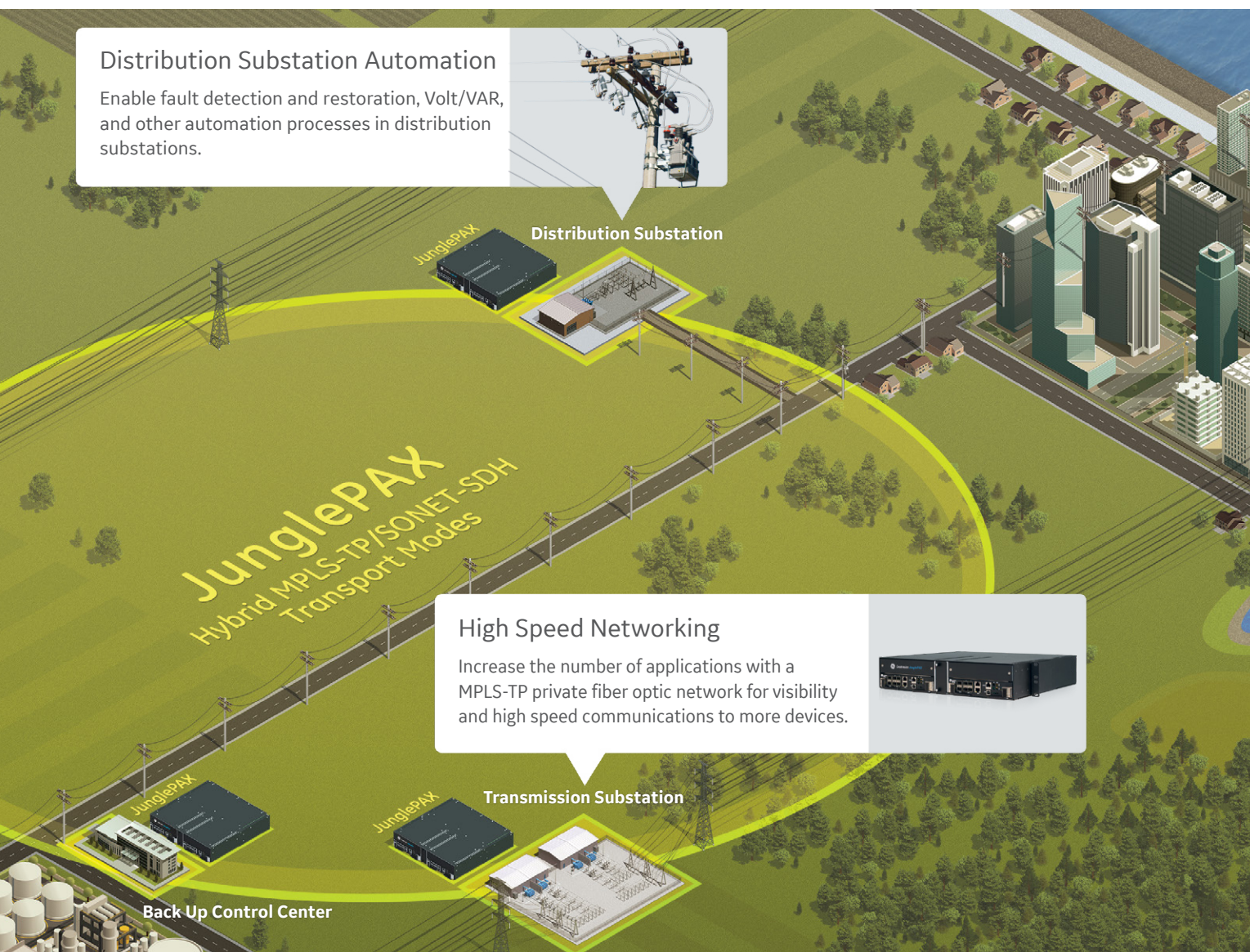


Changing Environment

Without careful planning, essential operational applications may become compromised as new applications and technologies are layered onto the network.

New applications deployed at more locations and supported through newer intelligent field devices each generating more data place pressures on communication networks. Utilities challenged to protect the performance of their essential operational traffic while supporting these next generation service must additionally consider:

- The demand for real-time control in energy delivery and consumption, which requires new system visualization capabilities.
- Network integration of previously segmented and disparate networks from backhaul to the edge.
- The increasing pressure to lower the utility communications operational costs and total cost of ownership.
- Converging onto one network that increases system capabilities and reduces complexity.



GE's Solution

GE's Lentronics JunglePAX is a purpose-built fiber optic solution for high-performance industrial communication networks requiring mission-critical and time-sensitive communications within harsh utility environments. The platform provides private, secure, and reliable communication between collection/access sites, and guarantees performance over aggregation and backhaul networks for protection and/or control. The JunglePAX has been designed for utilities with standards-based MPLS-TP for superior performance of packet delivery and network operations, taking into consideration the operational and environmental conditions and addressing the communication challenges that utilities are currently facing as well as meeting future business needs.

The JunglePAX provides the following benefits:

- Designed for teleprotection and superior performance
- Single solution converging and simplifying operations
- Ruggedized and modular design lowering total cost of ownership

The JunglePAX employs an optimized version of the MPLS-TP standard for utilities that provides connection-oriented transport to enable security and dependability. The fully redundant and custom 1+1 protected CORE hardware provides redundancy for critical functions, including real-time control of traffic carried over the Wide Area Network (WAN) and between CORE modules, and a dedicated embedded management system (eMS) for system-wide element level management tasks.

Client services fed through dedicated Ethernet and TDM access modules into redundant CORE WAN modules where application-defined quality of service settings are applied. Hardware-assisted bidirectional fault detection (BFD) coupled with link down indication messages (LDI) and redundant paths allows for fast switching of all client services. The JunglePAX is industrially designed to protect the sensitive electronics from contaminations and is fanless, thus providing a perfect solution for imperfect substation environments.

Engineered Service Quality

JunglePAX employs trTCM-ColorBlind and trTCM-ColorAware Policing Schemes per RFC 4115 for Ethernet-based services. Both Policers and Monitors are available to users at access points and WAN ports (per service/pseudowire) to allow them to engineer SLA (service level agreements) across the entire service/pseudowire path.

For each Ethernet service, users define Committed and Excessive Information Rates (CIR/EIR) as well as Committed and Excessive Burst Sizes (CBS/EBS). The JunglePAX firmware calculates gross information rates for individual pseudowires to allow for accurate WAN link bandwidth engineering and real time monitoring of individual service/pseudowire contributions to each WAN link's bandwidth.

For TDM traffic carried over the MPLS-TP transport layer, bandwidth allocations on WAN links are automatic. Additionally, critical TDM traffic is assigned the highest priority for the best possible latency and packet jitter performance.

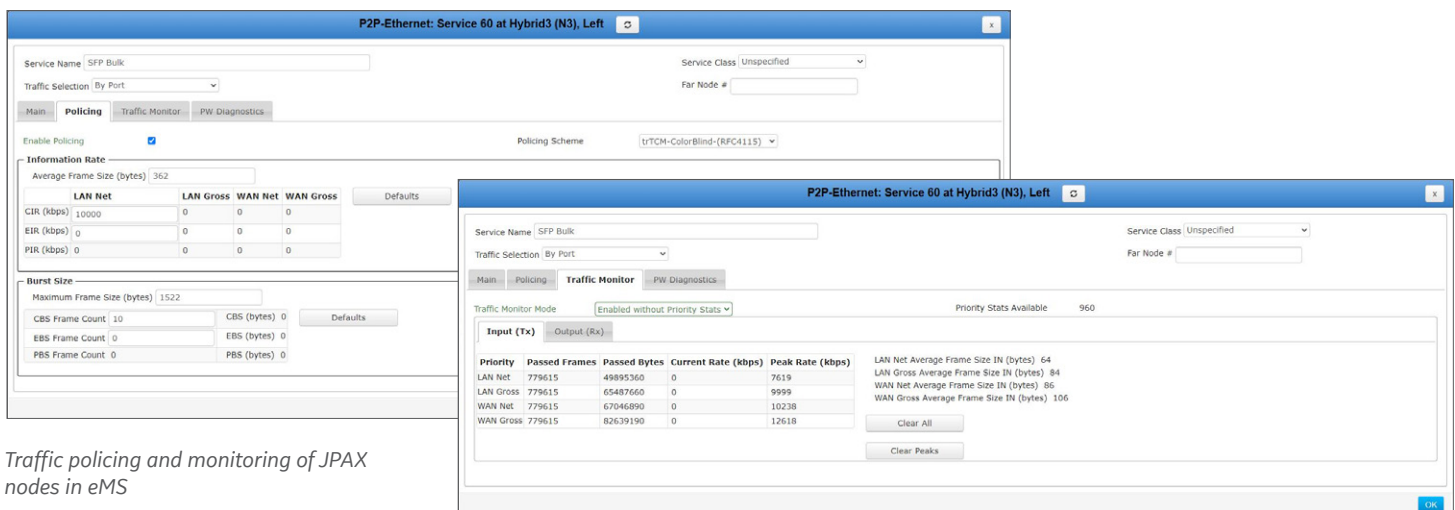
The TDM traffic carried over the SONET/SDH transport layer does not require any traffic engineering in addition to standard TDM bandwidth allocation. It also enjoys sub-millisecond latencies critical for mission critical teleprotection applications.

Ideally Suited for Teleprotection

The JunglePAX platform employs an optimized version of MPLS-TP to deliver teleprotection with utility-grade performance. Designed with layers of redundancy, there is no single point of failure, providing customers with an assurance that critical teleprotection circuits are delivered securely and dependably across the network.

Benefits of JunglePAX Networks Include:

- Perform critical low latency applications where security and dependability must be guaranteed
- Employ hardware-based fault detection with protection switching within 3 ms to restore services via route diversified paths (versus 50 ms for standard MPLS-TP/SONET/SDH equipment)
- Utilize Synchronous Ethernet (SyncE) to tightly control variability in transmission that affects critical communication services
- Support co-routed bidirectional paths to eliminate asymmetrical delays that affect critical communication services across a network
- Provide determinism via a connection-oriented approach to packet transmission
- Permit static assignment of working and protect paths to ensure application performance and eliminate complexity associated with dynamic control plane protocols



Traffic policing and monitoring of JPAX nodes in eMS

Single Solution for Converged Applications

The Lentronics JunglePAX has been designed as a single box solution primarily for critical operational traffic and additionally supports differentiated IT applications, eliminating the need for separate access, aggregate and core networking products. Through a flexible mix of interfaces and networking protocols, utilities can scale up or scale down to address the diverse needs of each application.

Key features of the single solution design include:

- Integrated Wide-Area interfaces and 16 local access ports supporting 64k, Nx 64k, TDM and 10/100/1000M Ethernet services
- Supports both Label Edge and Label Switching Router functions
- Built on open standards, interoperable for mixed-vendor heterogeneous environments
- Integrated (embedded) management system provides redundant, network-wide status and control without relying on an external NMS engine
- An external NMS solution capable of managing over a thousand device types via numerous protocols (SNMP, CLI, NETCONF) simplifies the network management model, thus reducing operating costs and complexity

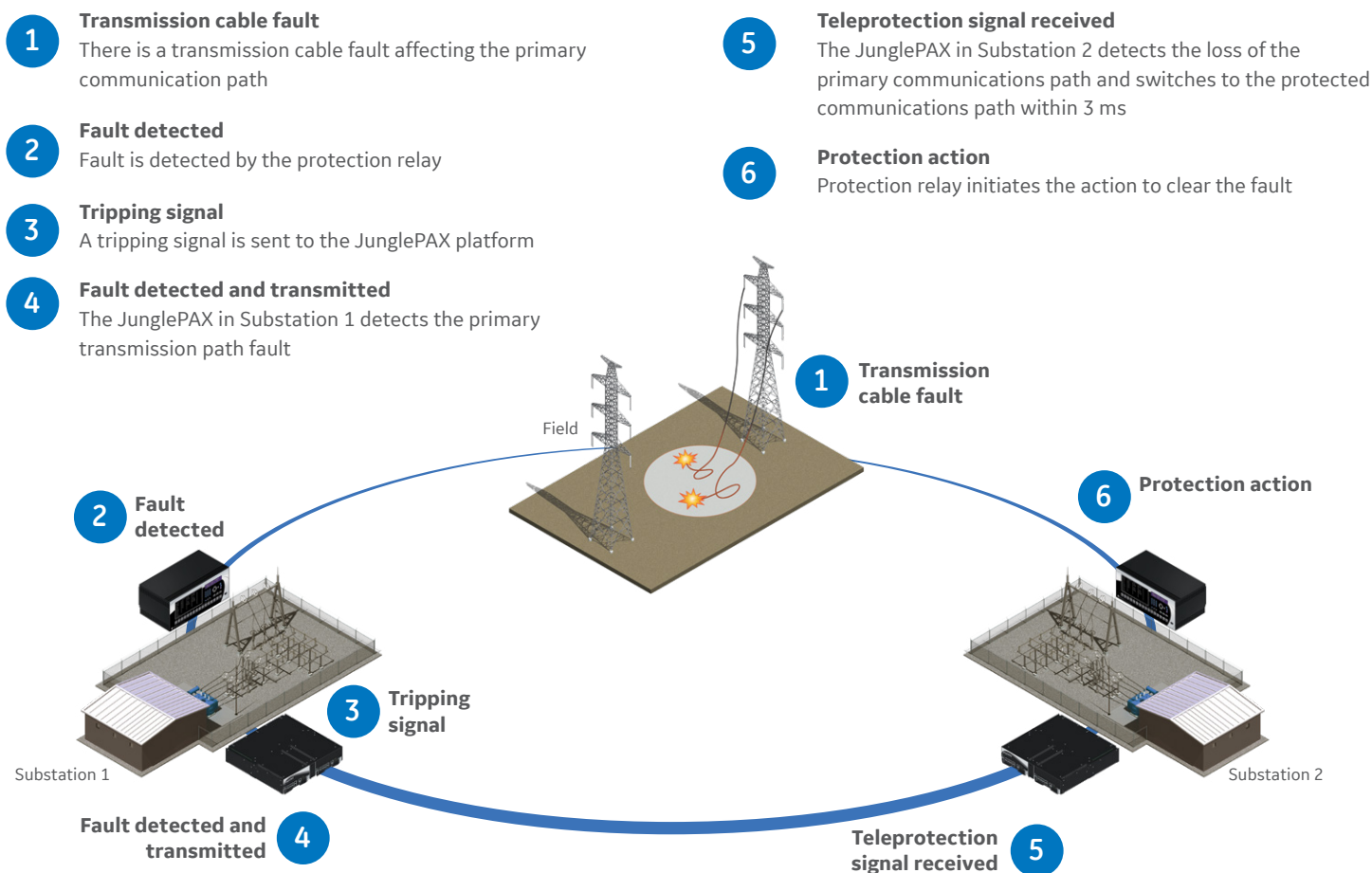
Teleprotection Application Example

Utilities are concerned about the impact on critical infrastructure and damage or injury associated with a fault condition on the transmission network. Teleprotection is a critical utility application that enables protection devices to communicate in a coordinated, reliable and expeditious way.

Distance or directional comparison relays require deterministic communications with low propagation delay edge-to-edge, or substation-to-substation, often within 8ms. The faster the tripping signal can be transmitted across network, the quicker the dangerous energized state can be removed. Due to their importance, tripping signals cannot tolerate network disturbances affecting availability, capacity, physical communication failures, maintenance-related outages or security vulnerabilities.

The JunglePAX platform provides protection switching within 3ms, and sub-millisecond latency for differential relaying applications carried over hybrid WAN links.

Typical Application Example of a Transmission Cable Fault



JunglePAX provides reliable inter-substation relay communications during primary communications path failures

Flexible Connectivity Future Proofs Investment

The JunglePAX platform has considerable flexibility and scalability, enabling wider deployment options and diverse network connectivity choices. The platform offers customers a solution to address the challenges of capacity constraints while maintaining essential service separation between disparate applications. JunglePAX is a converged platform that future proofs a customer's investment with a lower cost of ownership by offering flexible connectivity options to carry diverse packet and TDM-based client services.

Ruggedized for Longer Life

The JunglePAX is industrially hardened and designed for deployment in harsh substation environments where conditions are not optimal for traditional telecom equipment. The superior thermal design enables reliable operation across an extended temperature range without active cooling, enabling improved reliability, longer life and lower maintenance costs. The rugged, industrial features of the solution include:

- Designed for compliance to IEEE 1613 and IEC 61850-3, with no cooling fans
- Extended temperature range from -20°C to +60°C
- Immune to substation contaminants and foreign objects falling onto the equipment chassis
- Quality component selection / design for five 9's
- Hot-swappable modules

Simplifying and Securing Utility Networks

All utility applications require dependable communications, however not all applications require the same level of performance. Applying the right level requires definition of performance criteria for each application. Application Defined Networking (ADN) is an important concept built into JunglePAX to simplify and secure service provisioning. Due to the complexity and variance in configuring different service types across the network, complex and resource intensive control protocols are often employed that can impact service reliability. Within JunglePAX, ADN with static assignment simplifies and secures utility networking.

Each utility application requires a unique performance criteria, for example:

- A video surveillance application is serviced via an Ethernet interface that is often asymmetrical in nature and is multipoint, leveraging IP multicast protocols often requiring larger amounts of bandwidth.
- In contrast, line differential relaying applications are interfaced via low bandwidth N* 64 kbps service ports (IEEE C37.94) requiring point-to-point paths with engineered determinism, strict performance for low latency, jitter and zero packet loss with ultra-fast protection switching to ensure security and dependability. Line differential services must be bidirectional and completely symmetrical in nature.

Application Defined Networking Walk Through

The JunglePAX provides an application-defined approach to simplify and secure utility communications. Every defined service perceives the MPLS architecture as a single network device dedicated to its use. This is achieved in the following way:

1. Private optical networks are deployed at the physical layer to interconnect disparate utility assets
2. GE's optimized version of MPLS-TP virtualize the overall network to emulate a single switch or router to simplify the design
3. Application profiles capture unique criteria used to identify and qualify their security and dependability requirements
4. Each profile is applied to the network, enforced by the network and accounted by the network over the life of the application
5. Authorized applications traverse the network based on the assigned profile

Complete Portfolio of Teleprotection Interfaces

JunglePAX supports a complete portfolio of teleprotection interfaces including C37.94 (mmf and smf), G.703 64 kbps, RS-232 and Direct Transfer Trip (DTT) specifically designed for JunglePAX shelf mechanics. The respective cards can be flexibly installed into as many as 10 shelf slots. A choice of high density (4 ports per slot) or low density (1 port per slot) is available for all of them, except for DTT, which supports two bidirectional DTT circuits on a 2-slot card.

Additionally, JunglePAX supports all 64kbps level cards originally designed for JungleMUX, TN1U, TN1Ue, T1MX and E1MX shelf mechanics including the specialty interface cards for legacy pilot-wire relays including HCB, HCB-1, CPD, SPD, RADHL and DL-91. The sub-millisecond latency performance critical for these services is maintained by using the JunglePAX's SONET/SDH transport layer.



4-port G.703 iDSO unit (90366-01)



4-port C37.94 iDSO unit (90360-02)



2-port Direct Transfer Trip iDSO unit (90341-03)

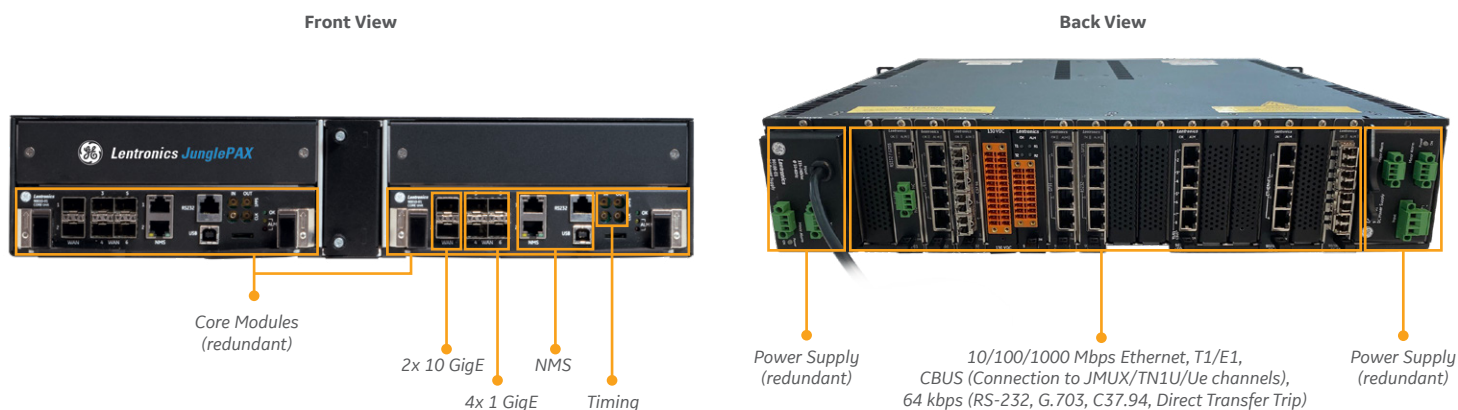
Migrating Data Channels to JunglePAX

CBUS interface modules provide access to existing and field-proven JungleMUX & TN1U 64 kbps channel units. For customers already using these interface units, retention of this equipment not only reduces the overall capital expense associated with equipment replacement, but also allows utilities to defer the added burden of recommissioning, documenting and training employees on new interfaces. These interface units have a proven track record with many years of field operation providing new and repeat customers alike with assurances that these application interfaces are thoroughly tested across hundreds of utility installations.

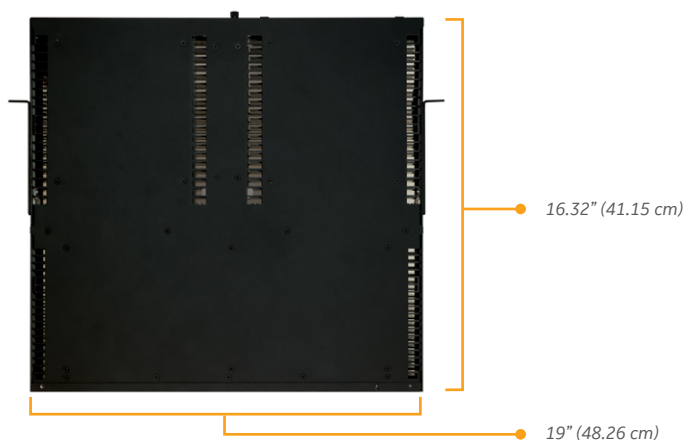


JunglePAX Components

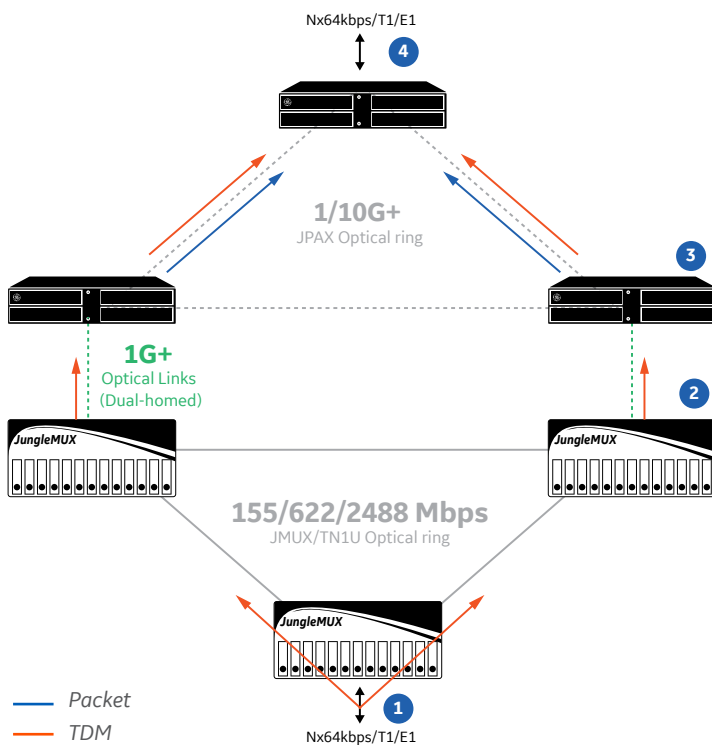
The JunglePAX is comprised of replaceable and hot swappable interface cards which ensure that the platform is easy to maintain. The flexible mix of access cards provides utilities with a solution that addresses changing communications requirements.



Platform Dimensions



90001-01: Shelf
19", 2RU, 2 Core, 2 Power, 1 Timing, 16 Access Slots



JunglePAX allows the flexibility of routing either Packetized traffic or preserving TDM end-to-end

Simplified Migration from JungleMUX/TN1U to JunglePAX Networks

The Evolution module allows for simplified migration of GE Lentronics SONET/SDH multiplexer networks to JunglePAX MPLS-TP/Hybrid networks on a ring-by-ring or node-by-node basis. The VT1.5/TU-12 traffic originated at JungleMUX/TN1U nodes can be terminated at JunglePAX nodes while its working and protect paths can be either partially or entirely carried over the SONET/SDH layer.

- 1 TDM traffic is presented into both left and right fiber directions (1+1 protection)
- 2 JMUX/TN1U node equipped with Evolution Modules pass the TDM traffic over 1G+ optical links to JPAX (single or dual-homed)
- 3 JPAX has the flexibility to convert the TDM traffic to packet or preserve the TDM traffic over a [Hybrid transport mode](#)
- 4 JPAX terminates the Packet or TDM traffic from both redundant fiber paths

Cyber Security

JunglePAX is built around a range of cyber-security standards, guidelines, and industry best practices for critical infrastructure and industrial control systems. Some of the standards include NERC CIP, NIST SP800-82, NISTIR 7628 and FIPS 140-2.

JunglePAX deploys a Secure Communications Framework consisting of:

- Digitally signed firmware
- Secure coding practices with Coverity code review
- Use of secure protocols including RADIUS, HTTPS, NETCONF, SNMPv3, and SSH
- Use of strong authentication, encryption and tunneling algorithms such as SHA-256 and AES 256
- Role-based access control and authorization
- Embedded security policy distribution
- Remote enabling/disabling of LAN and WAN ports
- Optional AES 256-bit encryption of MPLS-TP traffic on WAN ports
- Optional auto-disabling of disconnected operational LAN ports
- Restricted MAC access to LAN ports with optional intrusion detection
- Deployment of security alarms
- Extensive event logging

Optional AES 256-bit encryption of MPLS-traffic is available on all WAN ports. Once enabled on both sides of a WAN link, public/private keys are periodically rolled (configurable to a value between 0.5 and 200 hours). Keys can also be manually renewed on each segment via the Web User Interface.



Network Management

Lentronics™ Advanced Network Management solution is a complete suite of software tools to securely manage the GE Lentronics family of telecommunications products, consisting of JunglePAX Hybrid MPLS/SONET/SDH, JungleMUX SONET and T1 Multiplexers, TN1U/TN1Ue SDH Multiplexers and E1 Multiplexers.

Telenium™ Advanced Network Management

- Multi-Protocol, multi-vendor capable Manager-of-Managers (MoM) built on the latest Microsoft Windows Presentation Format (WPF) that simplifies infrastructure-wide network management
- Licensed to GE by Megasys computer technologies to converge multiple platforms onto one pane of glass, including SONET/SDH, MPLS-TP, Hybrid and Industrial Switch platforms
- Employs 'SmartTile' technology to enhance network equipment tasks and provide user-friendly graphical user interface

Key Benefits of Telenium™ Advanced Network Management

- Provides full FCAPS (Fault, Configuration, Administration, Performance and Security) support for GE equipment with
 - Complete JunglePAX system monitoring, configuring and edge-to-edge provisioning of all tunnels and services via NETCONF
 - Monitoring of SONET/SDH/T1/E1 multiplexer alarms, performance and activity logs via SNMPv3
- Provides a high-availability solution that allows operators to use all systems concurrently, and to ensure full connectivity of the underlying networks
- Is scalable; working with thousands of networking equipment vendor solutions to create an effective over-arching management solution that reduces complexity and operational expenditure (OPEX) of running multiple management solutions
- Is extendable; allowing customers to pay as you grow with new features and functionality
- The Escalation tool allow users to escalate issues automatically via email or SMS
- Advanced Logic Processor monitors and correlates events in real time across multiple systems

SmartTiles

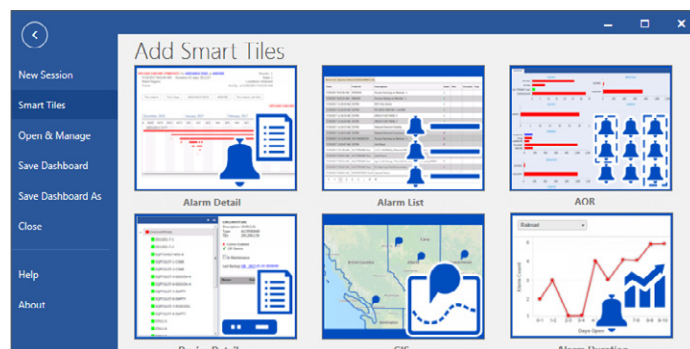
SmartTiles is an evolutionary user interface available within GE's Advanced NMS platform, that is gaining support across Telenium customers for the following reasons:

- Provide tile relationships (parent/child) for automatic tracking of actions
- Support combination of historical and real-time data correlation
- Implement powerful controls to maximize pattern recognition
- Standardized user interfaces between vendors' products supported within Telenium Spectra
- Supports custom tiles for niche products or application

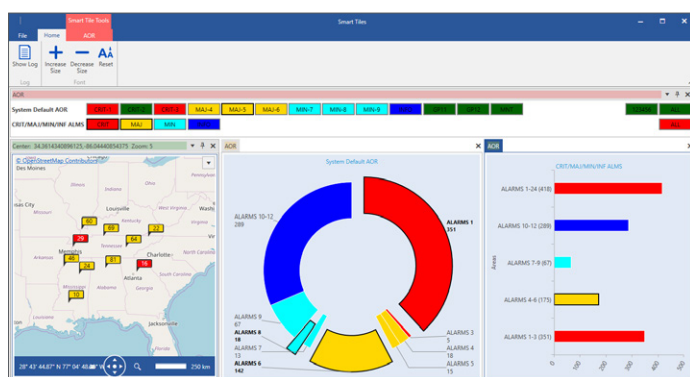
Numerous SmartTiles are already supported while new tiles are added regularly. A customized tile designed natively for JunglePAX will be released to all JunglePAX customers.

Embedded Management System (eMS)

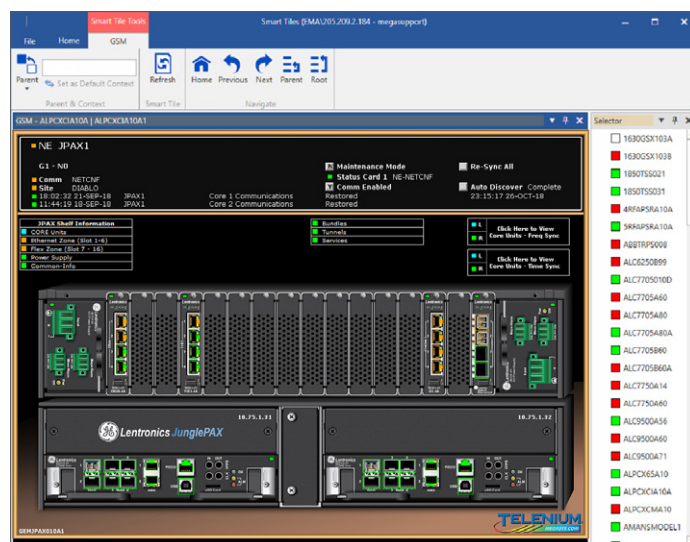
- Embedded element managers running at each JunglePAX CORE module providing operational staff with network-wide visibility from any node and without access or dependency on the Telenium NMS platform
- Offers CLI and HTTPS connections via a secure web-browser connection



SmartTiles



SmartTiles dashboard view



SmartTiles - Graphical Service Manager (GSM)

Technical Specifications

MULTI-SERVICE PLATFORM		
	Hybrid MPLS-TP/SONET/SDH platform, Modular in design with layers of redundancy	
	Hot swap of all redundant components without service interruptions	
	Utility hardened to ensure security and dependability	
	Non-blocking architecture	

WIDE AREA NETWORK (WAN) OPTIONS		
Optical WAN	Capacity	24 Gbps, redundant
	Number of 10G Optical WAN ports	2, SFP+, (up to 80 km)
	Number of 1G Optical WAN ports	4, SFP

NETWORK MANAGEMENT		
Management	Device management	embedded Management System (eMS)
	Network management	Advanced NMS (optional)
	High availability mode	1+1 protected
	Console port	USB
	NMS port	RJ-45, 100Base-T
	Inbound / Outbound interfaces	CLI, WebUI (HTTPS), SNMPv3 *, NETCONF

PERFORMANCE		
	CORE Hardware protection	1+1, 20G bypass
	Processors	Dual, Dedicated separately for Data Plane (DP) & Management Plane (MP)
	Transport Protocol	MPLS-TP (RFC 5654), Hybrid (MPLS+SONET/SDH)
	Encapsulation on Hybrid ports	WAN-Interface Sublayer (WIS)
	Quality of service	IEEE 802.1p/q with priority queues and priority scheduling; RFC 4115 metering and policing for Ethernet-based services
	Node transit delay	< 30 µs
Switching	Capacity	132G (172G with internal ports considered), excluding TDM services carried over SONET/SDH
	Fabric	Redundant
Backplane	Passive	Yes

Client services	TDM and Ethernet	TDMoP: Emulated TDM over PSN CESoPSN, SAToP) TDMoS: TDM over SONET/SDH Ethernet: E-Line, E-Tree and E-LAN Ethernet Virtual Connections, configurable max frame size (up to 12,000 bytes), 32k MAC addresses per node
Packetizer	T1/E1/CBUS TDM ports	8 on the Core Card (via T1E1-4A modules) and 8 for each xTDM module installed
Synchronization	WAN Synchronization method	SyncE
	Internal Modes	Headend with SSM, Freerun
	Accuracy	4.6ppm (Stratum 3)
	External modes	2 kHz, 10 MHz, 1 PPS, GPS *
Timing	Quality	SSM, ESMC
	Timing Protocols	NTP, IEEE 1588v2 (telecom and power) *
OAM	Accuracy	1us, Grandmaster (1588v2) *
	Fault Detection	LDI, 256 HW-assisted BFD per CORE
	Protection Switching	1+1: <3 ms on fiber break, ~0 ms on CORE module extraction 1:1: <16 ms on fiber break, <50 ms on CORE module extraction

SECURITY		
Security	EtherWAN encryption engine	6 independent encryption engines, optionally enabled on each WAN port
	Encryption	AES 256
	Authentication	SHA 256
	Key distribution	Public/Private, User configurable rolling key frequency
	Access Control	Role-based
	User Authentication	RADIUS
	Accounting	Syslog (local)
	Federal Information Processing Standard	140-2

CERTIFICATION		
Industry Compliance	SAFETY, UL, EU, CSA	UL 60950-1, ETSI EN/IEC 60950-1, CAN/CSA C22.2, RCM (Australia)
	Conducted and Radiated emissions	FCC Part 15B, CISPR/EN 55022, EN 300 386, VCCI, AS/NZS CISPR 22, CNS13438, and KN 22
	Immunity	EN 55024, EN 300 386 and KN 24
	Power Substation	IEEE 1613 (no cooling fans)
	Hardening	IEEE 1613 (no cooling fans), SWS, EMI, RFI, ESD, IEC 61850-3, IEC 60834-1
Environmental	Operating Temperature	-20°C to + 60°C
	Storage Temperature	-40°C to +70°C, IEC 60068-2
	Humidity, %RH	5 - 95%, non-condensing
	Altitude	3000 m
	Earthquake	NEBS ITL GR-63-CORE Issue 4*
	RoHS	RoHS / WEEE

POWER MANAGEMENT		
Power	DC	-48/130 VDC (ungrounded or +ve grounded), isolated inputs, hot swappable
	AC	120/240 VAC, 50/60 Hz, hot swappable
	Redundant	Yes
	Consumption	160 W, Overcurrent protection at 180 W per power supply

ACCESS CARD INTERFACES		
Access Card interfaces	Number of Access slots	16
	Hot swappable	Yes
4x1 GigE slots	EF-4A	4 x 1G/FE fiber ports, SFP, per-port configurable native VLAN ID
	EC-4A	4 x 10/100/1000 Mbps copper ports, RJ-45, per-port configurable native VLAN ID
1 GigE slots		6, using EF-4A and EC-4A units
	TDM slots	4 (16 if xTDM-8A cards are used)
T1E1-4A		4 x T1/E1 ports, RJ-48c, G.704, G.706, G.826
		E1 formats: PCM30/CAS, PCM31/CCS, Unframed
CBUS-4A		4x CBUS ports, RJ-48C
	xTDM-8A	8 x T1/E1 ports (G.704, G.706, G.826) or 4 x CBUS ports*, RJ-48C
64 kbps slots		10
	C3794-1A	1 x IEEE C37.94, mmf/smf, N x 64 kbps (N=1...12), SFP, LC connector
C3794-4A		4 x IEEE C37.94, mmf/smf, N x 64 kbps (N=1...12), SFP, LC connector
	DR-1A	1 x RS-232/V.24/V.28 (up to 38.4 kbps) or 1 x G.703 64 kbps codirectional
DR-4A		4 x RS-232/V.24/V.28 (up to 38.4 kbps) or 1 x G.703 64 kbps codirectional
	G703D-4A	4 x G.703 64 kbps codirectional
DTT-2A		2 x DTT Tx/Rx @48VDC, 130VDC, 250VDC

SIZE		
Size	Shelf	19" (48.26 cm) W
		16.32" (41.45 cm) L
		3.49" (8.86 cm) H
	Spacing	1RU above and below for circulation

ACCESS CARD COMPATIBILITY		
	Lentronics Access cards compatible with JPAX via the CBUS port	DTT Tx/Rx
		RS-232 / V.24
		Nx64E (electrical, V.35) and Nx64F (Fiber, C37.94)
		G.703
		CDR (HCB, HCB-1, CPD/SPD, RADHL, DL91)
		OCUDP
		2W FXS/FXO, E&M
		4W TQ, E&M
		RS-422 / V.11
		Contact IO

* future release

JunglePAX Ordering Codes

PART NUMBER	DESCRIPTION
SHELF	
90001-01	JunglePAX Equipment Shelf, 2RU, Modular, 2 x CORE, 1 x EXTERNAL SYNC, 16 x ACCESS, 2 x POWER
CORE - WAN	
90010-01	Core Module, MPLS-TP, Unlicensed, 2x 10G, 4x 1G capable
90010/10G	10 GigE WAN interface licensing
90010/G	1 GigE WAN interface licensing
90010/A, /B, /C, /E	SFP+, 10G, LC, SMF (10 km / 40 km / 80 km / 100 km) **
90010/AA, /BB, /CC, /EE, /GG	SFP, 1G, LC, SMF (10 km / 40 km / 80 km / 120km / 200km) **
POWER	
90110-01	DC Power Module, 48/130VDC
90100-01	AC Power Module, 115-240VAC, 50/60 Hz
EXTERNAL SYNC	
90081-01	Sync-In Module, 10MHz reference clock, redundant inputs
90081-02*	Sync-Out Module, 10MHz reference clock, redundant outputs
ACCESS	
90200-01	Ethernet Access Module, 4 x 1G/FE fiber, SFP
90200/AA	SFP, 1G, LC, 1310 nm, SMF, 10 km
90200/DD	SFP, 1G, LC, 850 nm, MMF, 300 m
86418/AA	SFP, 100M, LC, 1310 nm, SMF, 30 km
86418/DD	SFP, 100M, LC, 850 nm, MMF, 2 km
90201-01	Ethernet Access Module, 4 x 10/100/1000 Mbps, RJ-45
90300-01	TDM Access Module, 4x T1/E1, RJ-48C
90301-01	TDM Access Module, 4x CBUS, RJ-48C
90308-01	TDM Access Module, 8x T1/E1 or 4x CBUS, RJ-48C
90360-01	1 x IEEE C37.94, MMF/SMF
90360-02	4 x IEEE C37.94, 4 ports, MMF/SMF
90360/AA	SFP, C37.94, LC, SMF, 1310 nm, 15 km
90360/DD	SFP, C37.94, LC, MMF, 850 nm, 2 km
90350-01	1 x RS-232/V.24/V.28, or 1 x G.703 64 kbps
90350-02	4 x RS-232/V.24/V.28, or 3 x RS-232/V.24/V.28 and 1 x G.703 64kbps
90366-01	4 x G.703 64 kbps
90341-01	2 x DTT Tx/Rx @48 VDC, 130 VDC, 250 VDC

* Future release

** Other distances and CWDM/DWDM SFPs are available upon request

PART NUMBER	DESCRIPTION
CABLES	
90900-01	Serial Cable, USB
90901-01	Ethernet Cable, RJ-45 > RJ-45, CAT-5e, UTP, 3m
86485-99	Simple CBUS paddleboard for connections to JunglePAX CBUS card
90902-01	CBUS Cable, 2m, RJ-45 > IDC Socket (JMUX & TN1U)
90902-02	CBUS Connector, RJ-45 > DB9 (TN1Ue)
MANAGEMENT	
90000-02	Embedded Manager (eMS), per node RTU license
90000-50	Advanced NMS - Standard, per node RTU license, 1 client seat
90000-51	High-Availability Advanced NMS - Standard, per node RTU license, 1 client seat
90000-50/G	Advanced NMS - Gold, per node RTU license, 1 client seat
90000-51/G	High-Availability Advanced NMS - Gold, per node RTU license, 1 client seat
90000-55	Single client seat license

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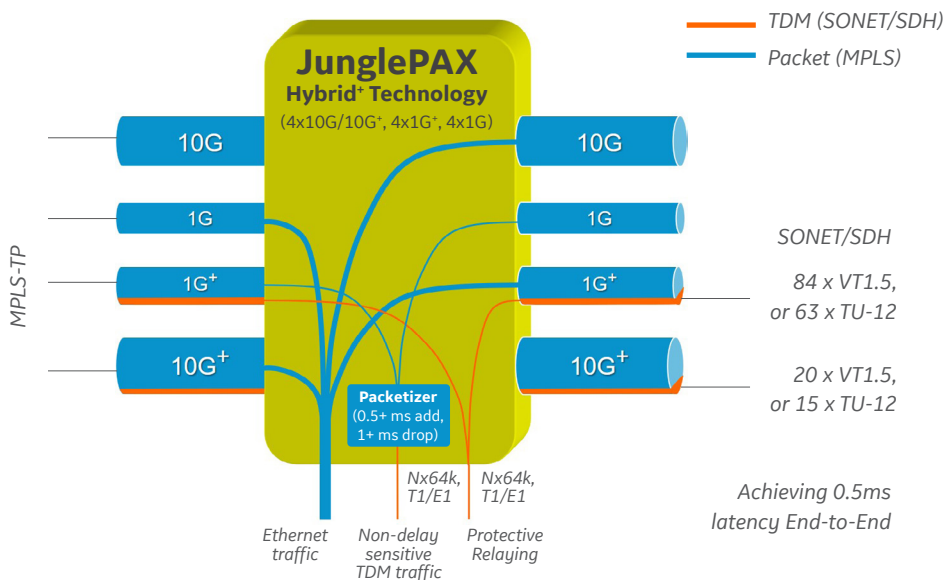
JunglePAX Hybrid⁺

Combining the Best of Packet and SONET/SDH Worlds in the Same Fiber

Packet-based transport technologies are being rapidly deployed in transport networks worldwide. Power utilities are no exception. While bringing unprecedented flexibility and manageability, these networks are not optimal for carrying traditional TDM services. This is primarily due to increased end-to-end delays associated with their emulation over packet-switched networks (PSN).

In the relaying world, faster is superior. Though many factors weigh into high-voltage line protection communications schemes, deterministic delay margins are critical. For line differential, asymmetrical delays also play a vital role. Relay vendors and protection & control engineers that have leveraged SONET/SDH transport networks with proven delay performance and determinism know this and are reluctant to migrate to PSN. In contrast, communication engineers, who understand advantages of migrating to a PSN for IT and traditional OT services, are challenged to deliver a converged solution providing both the performance for teleprotection and flexibility for all other services.

JunglePAX Hybrid⁺ Technology is the answer. It offers the best of both worlds by preserving SONET/SDH performance in a packet-switched network. This is achieved by adding an independent SONET/SDH layer alongside the MPLS-TP layer (without impacting its capacity) over the same optical WAN link. Use of this layer is optional and is intended for TDM-based relaying applications (C37.94, RS-232 Mirrored Bit, G.703 64k etc.) that are extremely delay sensitive.



Features & Benefits

- Supports packet-over-packet, TDM-over-packet (TDMoP), and TDM-over-SONET/SDH (TDMoS) transport over the same fiber
- Achieves sub-1ms communication delay to better protect critical Infrastructure
- Delivers JMUX/TN1U latency without QoS or traditional packet-based traffic engineering
- Worry-free transfer of existing TDM-based teleprotection services to packet-based transport infrastructure with guaranteed SONET/SDH-like performance
- Built-in interlayer converter for easy transition between SONET/SDH and MPLS-TP layers
- Allows for evolution of existing GE JungleMUX/TN1U networks to JunglePAX MPLS-TP networks in a ring-by-ring or node-by-node fashion

WAN Interfaces

- 4 x 10G⁺ and 4 x 1G⁺ hybrid WAN ports
 - 10G⁺ : 10G MPLS-TP + 20 x VT1.5* / 15 x TU-12**
 - 1G⁺ : 1G MPLS-TP + 84 x VT1.5 / 63 x TU-12
- 4 x 1G MPLS-TP non-hybrid WAN ports
- 10G⁺ WAN ports are convertible to non-hybrid

Superior TDMoS Delay Performance

- 0.5 ms end-to-end delay (back to back)
- 17 μs pass-through delay (express mode)

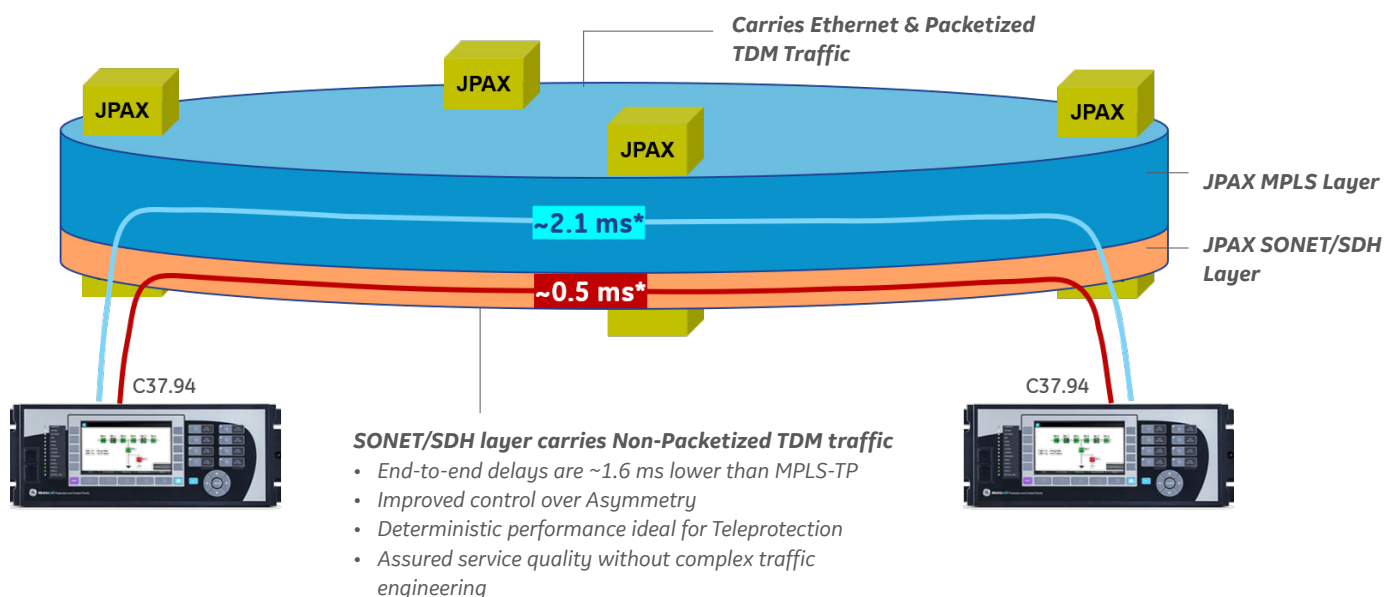
* VT1.5 is a virtual tributary supporting 1.5Mb/s signals

** TU-12 is a tributary unit supporting 2.048Mb/s signals



Modernizing optical communications infrastructure without performance impact

Hybrid* Technology found only in JunglePAX permits migration from SONET/SDH to Packet-transport technologies without compromising application performance, equipment reliability and network-wide availability.



* Excluding node-through delays and fiber propagation delay (~8 μ s/mile)

	TDMoS	TDMoP
End-to-End Delay*	~ 0.5 ms	~2.1 ms
Node Through Delay	Deterministic <ul style="list-style-type: none"> • 17 μs (express, at ADM node) • 26 μs (at cross-connect node) 	<ul style="list-style-type: none"> • 10G to 10G (L-R CORE, 64/1518 byte frame): 6.5/8.9 μs • 10G to 1G (L-R CORE, 64/1518 byte frame): 10.4/19.9 μs • 1G to 1G (L-R CORE, 64/1518 byte frame): 14.3/30.8 μs • 10G to 10G (Local CORE, 64/1518 byte frame): 4.1/5.3 μs • 10G to 1G (Local CORE, 64/1518 byte frame): 8.2/16.3 μs • 1G to 1G (Local CORE, 64/1518 byte frame): 12.2/27.3 μs <p>NOTE: These are average values. Assuming no added queuing delays due to large/jumbo frames in lower priority queues.</p>
Delay Asymmetry	< 130 μ s	< 250 μ s
Protection Switching Time (1+1)	< 3 ms (path failure) ~ 0 ms (CORE card extraction)	< 3 ms (path failure) ~ 0 ms (CORE card extraction)
Protection Switching Time (1:1)	n/a	<16 ms (path failure) <50 ms (CORE card extraction)

* Excluding node through delays and fiber propagation delay (~8 μ s/mile)

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GEA-33160-(E)
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Evolution Module

Evolving and Modernizing Optical Communication Infrastructure

GE's JungleMUX hardened optical networking solutions have protected our customers most critical assets ensuring safe and reliable delivery of services within harsh industrial environments for over 25 years. Over this period, the product has evolved as technology trends and customers needs have changed, leading to new innovation that's extendable and interoperable with the core platform operation.

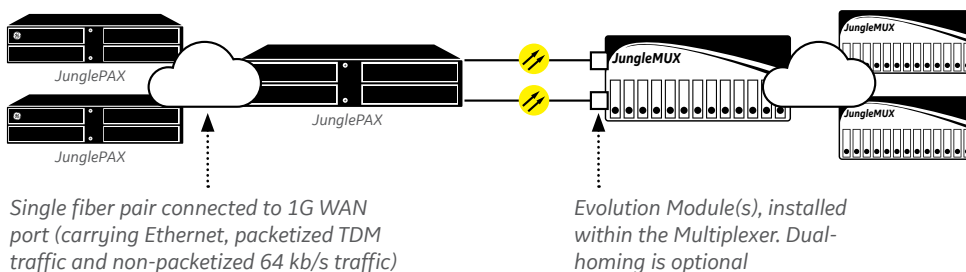
Currently, change comes in the form of an entirely new technology, MPLS (via GE's JunglePAX), a label switched approach for service deployment edge to edge. This is not a replacement for JungleMUX but instead an evolution of the Lentronics Optical Networking family of products, a strategy that's convenient, consistent and controlled.

Evolution Module (B86900-01) enables migration to MPLS ring by ring or node by node and offers an upgrade opportunity to modernize hardware while preserving highly dependable SONET/SDH delay performance for critical services through deployment of JunglePAX Hybrid Mode. Evolution and Hybrid work together to ensure ongoing security and dependability across both SONET/SDH and MPLS planes.

Our evolution strategies are consistent, convenient and controlled for customers using GE's optical multiplexers. We ensure migration from SONET/SDH to packet technologies without compromising application performance, equipment reliability and network wide availability.

Evolution Module

An Evolution Module is first installed in GE JungleMUX OC-3, 12 & 48 or TN1U/TN1Ue STM-1, 4 & 16 nodes, then optically connected via the units' SFP transceiver to a GE JunglePAX node via it's 1G+ WAN Port. A JunglePAX can be programmed to extract the entire contents of the Bulk VT1.5 / TU-12, or a selection of shared channels. Each 64kb/s channel can then be carried across the JunglePAX network through an MPLS (packetized) or SONET/SDH (non-packetized) service using JPAX's Hybrid Transport Mode.



Example of Evolution modules used to bridge 64kb/s and TDM traffic from SONET/SDH networks into JPAX



Features & Benefits

- New interface unit equipped at strategic JungleMUX or TN1U/TN1Ue nodes
- Offers a 1G+ Optical Interface for connection to GE's JunglePAX
- Passes TDM (VT/TU) Traffic from SONET/SDH to MPLS or Hybrid networks

Protects Existing Investment

- Evolution modules enable new JunglePAX nodes to interoperate within GE's SONET/SDH networks
- SONET/SDH rings are preserved to maintain network wide application performance

Works with JunglePAX Hybrid Transport Mode

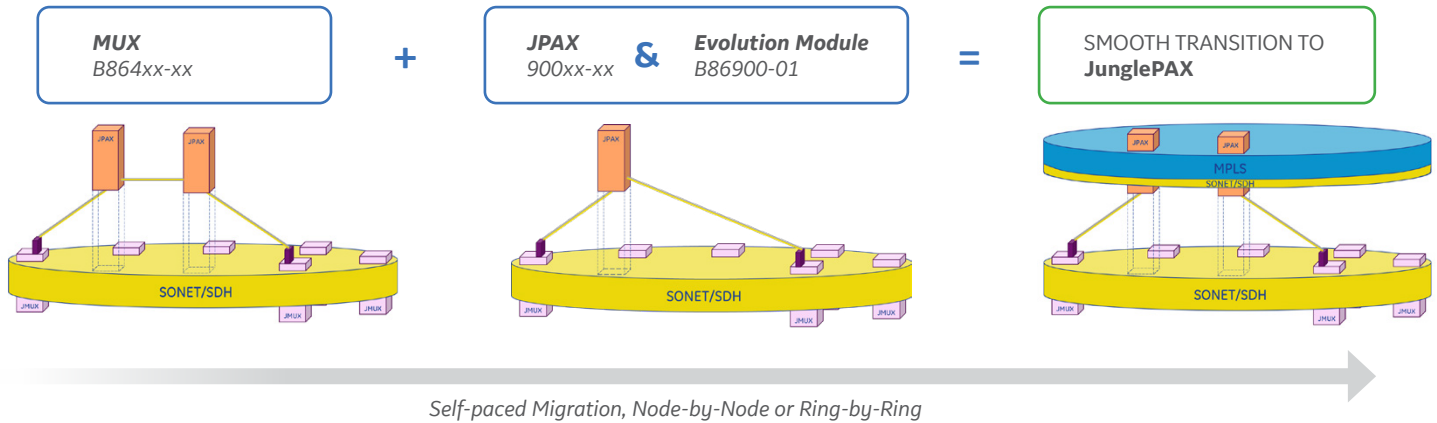
- To bridge 64k and channelized T1/E1 traffic between SONET/SDH & MPLS network boundaries
- Enabling the creation of Hybrid networks comprised of JunglePAX, JungleMUX & TN1U/TN1Ue platforms
- Supports Single or Dual-homed ties between networks
- Preserve 64k & TDM traffic integrity by bypassing packetization, delivering
 - Exceptional traffic performance (low latency & Symmetry) equivalent to TN1U/TN1Ue Multiplexers
 - SONET/SDH-like determinism without traditional packet-based traffic engineering and Quality of Service complexities



Evolving and Modernizing Optical Communication Infrastructure

Evolution Equation

Evolution Module further simplifies the migration from JungleMUX/TN1U/Ue Multiplexers to JunglePAX on a ring-by-ring or node-by-node basis. When adding new or modernizing existing substations, utilities may now insert a JunglePAX node into the pre-existing SONET/SDH network without service impact. This strategy enables a 'self-paced' migration of the optical communication infrastructure until the entire network is upgraded.

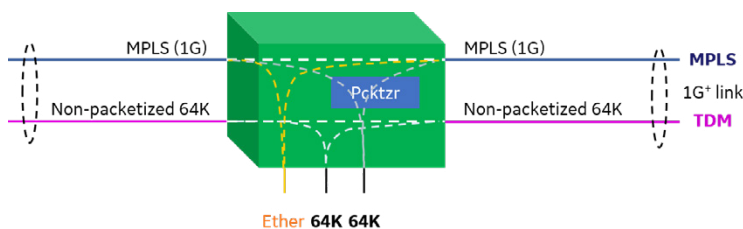


Hybrid Mode

When migrating from SONET/SDH to Packet, utilities must

- Preserve the highly dependable performance for critical and time sensitive applications, and
- Guarantee Interoperability between the platforms.

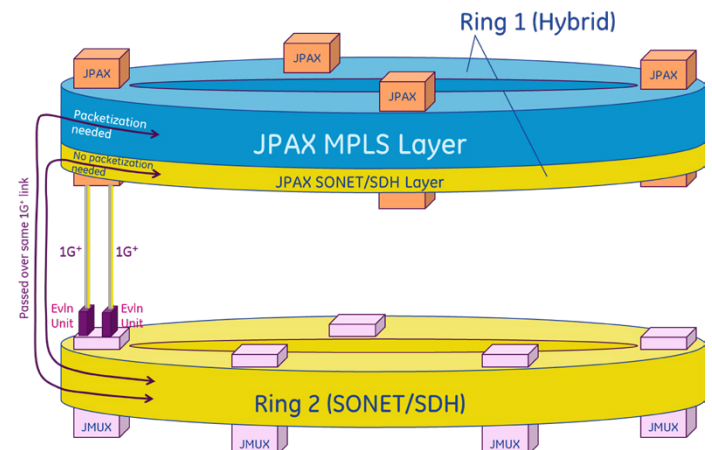
The JunglePAX offers a unique Hybrid Transport Mode to achieve both, supporting native TDM and MPLS streams on the same fiber. 64kb/s Teleprotection traffic carried over the JunglePAX network can do so without packetization, improving latency, asymmetry and determinism.



Evolution Modules and Hybrid Transport Mode work together to ensure ongoing security and dependability across both SONET/SDH and MPLS transport layers.

Hybrid & Evolution working together

When combined, Evolution Module optically connect JMUX/TN1U/TN1Ue nodes with JunglePAX at single tie site or dual-homed to further improve the network reliability. Operational Traffic (OT) can flow between the two networks uninterrupted and without any protocol conversion or packetization to preserve the performance for each services.



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Telenium Key Features

This document outlines many of the key features required by a network management system.

✓ **Common Off-The-Shelf (COTS) Product**

The network management system should be available without extensive customization by the vendor or the customer.

✓ **Multi-Vendor Capable**

The system must be able to support equipment from all vendors used by the customer, and using the best native protocol to provide the best management interface. Management of JunglePAX MPLS-TP products are supported through NetConf (RFC 6241 – 6243).

✓ **Multi-Protocol Capable**

The system must support many different protocols concurrently to network elements. In some cases, the same network element may require more than one protocol to return the best management information. Protocols that must be supported include TL1, PDS, SNMP (v1, v2c, v3), TBOS, DNP3, DCP, SYSLOG, NetConf, etc.

✓ **Synchronized Databases**

Allow for database synchronization of geographically separate network management systems. All systems must be able to be used at all times and any changes made to one system are automatically reflected on the other system including acknowledgement of alarms, database modifications, historical data, database changes, provisioning commands, rules and policies, etc.

✓ **Highly Scalable Platform**

The system must allow for significant growth without requiring system down time. Adding network elements, protocols, additional users, must all be allowed for online with a minimum of 100% growth of the system.

✓ **High Speed Database Processing**

At least 500 alarms per second must be supported by the system without significant degradation to the overall system performance.

✓ **User Authentication**

Allow for user accounts to be authenticated using LDAP, Radius, RSA or Kerberos.

Permit multiple levels of user accounts to be defined such as operators, technicians, administrators, security, etc.

Allow for the grouping of users into “logon groups” so that the rights and privileges assigned to the logon group are automatically inherited by the individual logon accounts associated with that group

✓ **User Policy Controls**

The system must support policies to control what rights each user or user group is authorized for. This must include restricting database modifications, command and control to network elements, deleting or changing historical data.

✓ **Fully Encrypted Data Exchange**

All data exchange between the user applications and the servers must be encrypted. Similarly, any browser interfaces must support HTTPS.

✓ **Network Element Account/Password Control**

When possible, the system should be able to manage accounts and passwords on all network elements without requiring an operator to log into each device. This must include the ability to change accounts and passwords on a regular basis.

✓ **Network Element Firmware Control**

When possible, the system should be able to determine the firmware versions operating within network elements and generate compliance reports against a customer defined list of acceptable releases.

✓ **Auto-Logon to Network Elements**

Where possible, the system should permit a user to log in to a network element directly but prevent the user from having to know or even see the password. Restrictions through policies are required to prevent some users from having this right.

✓ **24x7 Connectivity to all Network Elements**

The system should be connected to all network elements 24 hours per day, 7 days per week. For those network elements that do not support a connection based protocol (such as SNMP), health checks are required on a customer defined frequency to ensure the devices are responsive.

✓ **Automatic Alarm Correlation**

The system must automatically correlate the normalization of an alarm to its alarm state so that active alarm lists only show the current conditions and not simply an indication that alarm points have changed state.

Further, alarms must be correlated to the proper component within a network element when possible. That is, if an alarm impacts a card on a network element, the card itself must have a graphical indicator that it has an alarm.

Alarms relating to traffic must also be correlated to the specific card the traffic is connected to.

✓ **Automatic Alarm Propagation**

The system must automatically propagate alarms through the database so that alarms can be detected any level. For example, an alarm must be available automatically within the list of alarms for the card the point is on, within the shelf the card is contained in, within the network element, and within the site.

✓ **Performance Data Measurement**

Any type of analog or performance data must be supported by the system. The system must support automatic retrieval of PM and analog data, compare that data against customer defined thresholds, and generate alarms. Multiple threshold limits must be definable and requesting of PM data must occur in the background regardless of user interaction.

Trending of PM data is also required to permit viewing of the data over an extended period of time.

✓ **Synchronization of Alarms from Network Elements**

The system must synchronize standing alarms in the network elements to the network management system. It is not acceptable to only process new alarms and events. Further, and especially for SNMP devices, it is imperative that a periodic, and automatic, re-synchronization occur in case an alarm was missed.

✓ **Automatic Filtered Alarm Lists**

The system must be able to show filtered alarm lists at any level of the graphical interface. These lists should be filtered to the context of icon or element chosen within the graphical interface.

✓ **Extensive Alarm Priorities**

A large number of alarm priorities are required to distinguish service affecting, non-service affecting, critical, major, minor and other alarms from different types of devices (optical, microwave, electrical, environmental) and color association to those priorities must be done at the database level. Blinking colors are required for unacknowledged alarms.

✓ **Automatic Email with Acknowledgement and Escalation**

The system must support the ability to send out alarms by email based on extensive criteria such as on-call registers, technologies, day of week or hours of the day, etc. If the recipient of the email responds, escalation of the email is suspended otherwise emails are sent to higher call-out tiers after a configurable period of time.

✓ **Ability to Define Advanced Alarm Handling**

The system must allow for advanced alarm handling such as placing network elements or components into a maintenance mode, suppressing alarms for a defined period of time, moving a series of alarms into an incident that can auto-acknowledge alarms until the incident is over, performing advanced correlation such as detecting a loss of AC power alarm and correlating that to the generator running.

✓ **Areas of Responsibilities**

The customer must be able to configure areas of responsibilities that allow a single click access to any number of these AORs. An AOR may be comprised of specific alarm priorities/severities, geographical sites, equipment types, technologies (microwave, fiber, electrical, environmental), data rate (Ethernet, T1, OC3, etc.) or any combination of the above. AORs must allow for multiple inclusions, that is, Ethernet alarms may exist in an Ethernet AOR but also in an Ethernet equipment AOR.

✓ **Site Isolation Detected**

A real-time presentation of sites that are experiencing loss of communications is required. This display must show each site that has at least one device that is currently experiencing communication failures. The display should show the number of network elements that are failed and change color based on exceeding a specific threshold of failed devices.

✓ **Traffic Flow Discovery**

Where possible, to automatically determine the layer-1 network topology and how traffic traverses across the topology.

✓ **Traffic Association to Facilities and Network Elements**

Determine traffic associations to facilities and network elements so that alarms can automatically indicate which circuits and/or facilities are impacted. This also allows for determining the impact on traffic when scheduled maintenance is performed.

✓ **Circuit and Service Traversal**

Where possible, the system must be able to determine how traffic traverses through network elements and across layer-1 topology. For TDM type circuits, this must include timeslot allocation for calculation of network utilization.

✓ **Dynamic Representation of Networks, Circuits, Facilities**

The system must present network, circuits and facilities in a dynamic presentation format so that as network elements are added or changes in cross connects are detected, the presentation of the circuit does not have to be manually adjusted.

✓ **Generator Management**

Advanced generator management capabilities are required such as detecting a loss of AC power and raising an escalated alarm if the generator does not start within a user defined period of time. Similarly automatic capabilities such as detecting a reduction in fuel levels when the generator is not running should be alarmed to indicate an environmental or security issue.

✓ **Tower Light Management**

Advanced tower light management capabilities are required such as detecting that the day/night mode of a tower light has not switched based on the time of day and taking into consideration the day of the year. Therefore, in winter when nights are longer, the system should automatically adjust for when it expects the tower lights to change to the appropriate day or night mode.

✓ **Network Element Automated Configuration Backup**

The system, where possible, must be able to automatically retrieve network element configurations and store those backups for access by technicians should a configuration require reloading. More than one backup must be maintained and the backup schedule must be configurable.

✓ **Built-in GIS**

The system must come with a built-in GIS so that geographical presentations can be viewed without Internet access. Alarm severity colors must automatically propagate to the GIS views and placement of icons on the GIS must occur automatically based on the GPS location of a network element.

✓ **Automatic Overlay of Lightning Strike Data on GIS**

The system must be able to query the Viasala lightning string database and overlay the GIS presentations with real-time active lightning information.

✓ **Ability to build Custom Graphic Presentations**

The customer may want to build custom graphics that are dynamically updated with colors, context sensitive capabilities, right-click functionality, etc. No programming skills should be required and the ability to import background images from Visio or standard JPG files must be supported.

✓ **Context Sensitive System to launch Customer Websites and Applications**

The system must support the ability to define context sensitive detection and launching of customer applications and pass information based on the context of the activation. Similarly, the ability to launch a browser with a configurable URL based on the context of the launch must be supported.

✓ **Tools to Compile MIBs and Define Trap Handling**

The system must come with the tools required to compile SNMP MIBs and define trap handling. This tool may be used by the customer for simple devices rather than going back to the vendor for the work.

✓ **Long Term Historical Data**

The system must record all alarms, events, and performance data into historical files to hold for at least one year. Historical data should be SQL based to allow for customer written reporting and analysis. No modification of historical data is to be permitted.

✓ **Long Term Audit Data**

The system must record all audit reports such as database changes, provisioning commands issued through the system, user logon/logoff of the system and alarm acknowledgement into historical files to hold for at least one year. Historical data should be SQL based to allow for customer written reporting and analysis. No modification of historical data is to be permitted.

✓ **Built in Reporting with Custom Report Options**

The system must come with an extensive out-of-the-box set of reports but must also allow the customer to develop their own custom reports, pulling data from historical data, audit data, or the active system itself.

✓ **Trouble Ticketing System**

The system must come with an embedded trouble ticketing system or alternatively, be able to interface to the customers' own system. Alarms that are associated with tickets should show the ticket number on the display and be retained in historical files. Additional alarm points can be added later to a ticket and ticket closure codes should be configurable.

Telenium System Advantages

- ✓ Telenium is a turn key network management solution with no hidden costs.
- ✓ Your investment is protected by a 100% money back guarantee.
- ✓ Telenium is the NMS of choice for many utilities in North America and abroad.
- ✓ MegaSys ensures that Telenium complies with NERC/FERC and CIP requirements, and we strive to meet those evolving standards.
- ✓ Telenium has a vast inventory of supported network elements currently in use at customer sites, minimizing required development and greatly reducing the technical risks during deployment.
- ✓ Telenium is the only network management solution that goes beyond simple alarm handling and incorporates a full understanding of circuit traversal through your entire network.
- ✓ The effort required to implement a Telenium system is minimal, as all the correlation logic for alarming is automatic.
- ✓ MegaSys is not affiliated with any NE manufacturer, which allows our customers to select the best products for their network without being limited to specific hardware vendors.
- ✓ Telenium has won numerous awards from the UTC (Utility Telecom Council) including “Best Telecom Services Product” on five separate occasions, as well as the inaugural UTC “Impact” award issued “to honor the UTC Associate Member Organization making a great impact on our industry through an innovative and proven solution.”
- ✓ MegaSys provides a high-availability truly synchronized solution that allows operators to use all systems concurrently. This provides our customers with very high availability instead of having a system that requires a manual transfer to the backup system. Every change to the database is synchronized so you don't have to transfer files, rules, procedures, or anything else between the active and backup systems.
- ✓ Telenium offers SGX, a unique solution for the secure sharing of information between utilities.
- ✓ Only Telenium offers network element backups on a scheduled and automatic basis using any combination of FTP, TFTP, CLI, TL1 and other protocols, while allowing you to keep the last 10 good backups that are then accessible by the field technicians via HTTPS connections to restore a failed device.
- ✓ The Telenium system automatically uploads all standing alarms from the devices to ensure your operators see all the alarms, not just the new ones. Without the active alarms, there is no way to accurately represent the state of the network. Telenium is the only system that synchronizes active alarms from the network elements into the management system. Every equipment manufacturer has a different technique to make the standing alarms available, and it is critical that a network management system can retrieve these alarms to ensure that operators are completely aware of the active network conditions without being required to connect into the actual device to confirm the device status.

- ✓ Telenium comes with predefined alarm correlation eliminating the need to spend months of time programming rules.
- ✓ Telenium's advanced NE model architecture means that only the Telenium system understands how traffic flows through the devices. Telenium does not simply show alarms, it interprets how alarms impact traffic and, with the Service Management Layer (SML), it provides operators with circuit layout records based on how the equipment is behaving and associates alarms to the circuits, facilities and customers. The Telenium system will help you document your entire network with incredible accuracy, because it interrogates the equipment for its cross connects and validates end-to-end circuits knowing network topology, bandwidth assignment, and constituency relationships (i.e. that VT1.5s are constituent to an STS rate which may be cross connected or constituent to an optical channel.)
- ✓ The Telenium Network Management system supports direct communication to many different types of devices including VistaNet, DPS Telecom RTUs, and can receive alarms from other management systems such as SolarWinds, and Castlerock. Many of these devices use advanced protocols that other management systems cannot handle concurrently. Not only can Telenium concurrently communicate to devices via SNMP, but also with TL1, PDS, DCP, DNP3, TBOS, MCS-11, DLINK, and many other communication techniques. Our customers select the best products for their requirements without restricting the devices to a very limited set of protocols supported by typical network management systems, eliminating the need for intervening management systems, as well as the associated costs.
- ✓ Telenium communicates with many different devices from many different manufacturers, all concurrently and in their native protocols, negating the requirement for any other management platforms. It can issue provisioning commands to most devices, something other systems cannot do, enhancing the value that the Telenium system offers. For example, Telenium can download RTU configurations into DPS Telecom RTUs as well as process every alarm and event generated by the DPS devices. Furthermore, operators can also issue the controls on the RTU to close contact points. Subsequently other DPS management systems could be eliminated entirely. The same applies for many other devices from other manufacturers where their management platform may not be required at all, and other management platforms can be eliminated since Telenium supports all the capabilities of products such as Castlerock, What's-Up-Gold and Solarwinds.
- ✓ Additional features:
 - Telenium includes the ability to display Visio drawings with real time information overlaid automatically.
 - Telenium's Advanced Logic Procedures provide valuable features such as monitoring and correlating generator run times, fuel consumption, EPA compliance and weekly gen-tests.
 - Telenium users can escalate issues automatically with Email and Escalation.
 - A graphical editor gives customers the ability to create custom graphics in house.
 - GIS (Mapping) with automatic placement of sites onto the GIS display.
 - Built-in capability to interface to Viasala (requires a license to access Viasala).
 - Telenium supports additional add-on features, such as integration with ESRI, Salesforce, Remedy, and other ticketing systems.

- ✓ MegaSys works with our customers to assist with system deployment, and even adds new custom features and capabilities suggested by our customers.
- ✓ The Telenium Network Management System has a very short deployment period, less than 60 days if required.
- ✓ **No other system on the market today compares to the complete network management solution offered by MegaSys.**