THE FUTURE OF SMART GRID COMMUNICATIONS

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MAY 2014
THE GRID OF THE FUTURE...

WIDE-SCALE DEPLOYMENT OF RENEWABLES

INCREASED ENERGY EFFICIENCY

PEAK POWER REDUCTION, DEMAND RESPONSE
THE GRID OF THE FUTURE...

IMPROVED RELIABILITY

LOWER ENERGY DELIVERY COSTS

CONSUMER PARTICIPATION
THE GRID OF THE FUTURE...

PERVASIVE DISTRIBUTED ENERGY RESOURCES

MARKET RETAIL TRANSACTIONS

MICROGRIDS

DISTRIBUTED CONTROL

DATA ANALYTICS
TRADITIONAL POWER GRID

GENERATION

TRANSMISSION

DISTRIBUTION
TRADITIONAL GRID APPLICATIONS

- TELEPROTECTION
- SUPPLEMENTARY CONTROL AND DATA ACQUISITION (SCADA)
- MOBILE WORKFORCE
- ENTERPRISE VOICE & DATA
- SUPPLY-DEMAND BALANCE
- SAFETY
- EFFICIENCY
TRADITIONAL GRID COMMUNICATIONS NETWORKS

- SMALL NUMBER OF ENDPOINTS
- MULTIPLE, SILOED NETWORKS
- LOWSPEED WIRELINE, WIRELESS
- LIMITED CONNECTIVITY BEYOND THE SUBSTATION
ICT FOR SMART GRID: FORCES OF CHANGE

- DISTRIBUTED GENERATION & STORAGE
- DISTRIBUTED SENSORS & CONTROLLERS
- NEW APPLICATIONS
- NEW SECURITY THREATS (PHYSICAL, CYBER)

Distribution Automation
Automated Demand Response
Microgrids
Electric Vehicles
Retail Energy Markets
Dynamic Line Rating
Wide Area Monitoring And Control
...

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SMART GRID

- ENDPOINTS++
- BANDWIDTH++
- DATA++
- DATA SHARING++
- SUPPLY-DEMAND VARIABILITY++
- UNIVERSAL CONNECTIVITY
- DIVERSE QUALITY OF SERVICE, RELIABILITY REQUIREMENTS
TOMORROW’S ELECTRIC GRID
CONVERGED COMMUNICATIONS NETWORK

Substations — Control Centers — Data Centers — Generation

External Networks — Edge Routers

Wireline Service
VPN, P2P Ether, VPLS, ...

Wireless
LTE, GPRS, ...

Leased Lines
E1, ...

Private
PLC, GPON, ...

Field Area Networks

IP WAN over Fiber, Microwave (MPLS)

ALL-IP (IP/MPLS) INFRASTRUCTURE
SUPPORT OF LEGACY APPS AND INTERFACES
SCALABILITY
MULTIPLE LAST-MILE OPTIONS
MISSION-CRITICAL PERFORMANCE, RELIABILITY, SECURITY

DA IEDs PMUs
EV Charging Stations
Mobile Workforce
DER EMS
Microgrids
Distributed Generation
Advanced Metering Infrastructure (AMI)
Traffic Aggregation
Substations

Field Area Network

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IP/MPLS MISSION CRITICAL NETWORK FEATURES

VIRTUAL NETWORKS

• Traffic Isolation
• Confidentiality
• Integrity
• Support of Legacy TDM interfaces

VIRTUAL PRIVATE LAN SERVICE (VPLS)
IP-VIRTUAL PRIVATE NETWORK (IP-VPN)

MULTIPLE VIRTUAL NETWORKS ON COMMON PHYSICAL NETWORK

VIRTUAL LEASED LINE (VLL)
IP/MPLS MISSION CRITICAL NETWORK FEATURES
HIERARCHICAL QOS

LESS OVERALL BANDWIDTH REQUIRED → LOWER OVERALL COST

PRIORITY AND BEST-EFFORT TRAFFIC EQUALLY WELL SERVED

PREDICTABLE PERFORMANCE
IP/MPLS MISSION CRITICAL NETWORK FEATURES
FAST RE-ROUTE, TRAFFIC ENGINEERING

FAST RE-ROUTE

<50 ms restoration

PROTECTION AGAINST MULTIPLE FAILURES

TRAFFIC ENGINEERING

• SELECTION OF BEST PATH

• BANDWIDTH RESERVED END-TO-END
TOMORROW’S ELECTRIC GRID
SUBSTATION DIGITALIZATION

- STANDARDIZED, IP-BASED CONTROL AND MONITORING (IEC-61850)
- STATE-OF-THE-ART CYBER-SECURITY
- SECURE NETWORK ACCESS FOR FIELD PERSONNEL
- VIDEO MONITORING, ACCESS CONTROL
- REDUNDANCY, RELIABILITY

IP/MPLS NETWORK (WAN)

IEC-61850 STATION BUS
PRIMARY WAN
SECONDARY WAN
7705 SAR
ZONE 1
ZONE 2
ZONE 3
IEEE 1580
GRAND MASTER CLOCK
IEMS
HMI
IDS/IPS
ENCRYPTION

IP/MPLS NODE

REDUNDANT L2 HARDENED SWITCH
PRINCIPAL L2 HARDENED SWITCH
IP/MPLS NODE

WIFI
HMI

FIREWALL

SECURITY ELEMENTS

NETWORK ACCESS

FIELD PERSONNEL

MONITORING UNITS

POWER ELECTRONICS

ALSTOM GRID

ERDF

RTE

Schneider Electric

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TRENDS IN SECURITY THREATS

- more destructive
- more complex
- more frequent
ITU-T X.805 SECURITY ARCHITECTURE
FOR COMMUNICATIONS SYSTEMS PROVIDING END-TO-END SECURITY

GLOBAL SECURITY STANDARD DEVELOPED BY BELL LABS
CYBER ATTACK ENTRY POINTS

- IP/MPLS Network
  - LAN
  - telephone
  - Intelligent Electronic Device
  - IP/MPLS Router

- CONTROL CENTER
  - internet
  - PABX
  - Network Operations Center
  - IP/MPLS network management
  - database
  - SCADA

- GENERATION
  - Intelligent Electronic Device
  - IP/MPLS Router

- SUBSTATION
  - TDM
  - Intelligent Electronic Device
  - Meter
  - CCTV
  - WiFi
  - Teleprotection Relay

- HOME
  - smart meter homes
END-TO-END SMART GRID COMMUNICATIONS NETWORK SECURITY

- Hierarchical QoS
- MPLS-TE
- Fast Re-Route

ENSURE HIGH AVAILABILITY

- Encryption
- Authentication

ENSURE PRIVACY & INTEGRITY OF DATA

- Firewall

CONTROL ACCESS

- NAT

CONCEAL & SIMPLIFY NETWORK TOPOLOGY

- IDS/IPS
- Anti-virus

DETECT SUSPICIOUS BEHAVIOUR

- Hardened Network Infrastructure

WITHSTAND CYBER ATTACKS

- Security Management

MONITOR & REPORT
ENCRIPTION

POINT-TO-POINT

OLD GRID

INTERNET

IP/MPLS
NETWORK

SMART GRID

ANY-TO-ANY
OPTICAL LAYER ENCRYPTION

SECURE, IN-FLIGHT PROTECTION OF MISSION-CRITICAL DATA

SMART GRID

10G ENCRYPTED

10G NOT ENCRYPTED

DATA/CONTROL CENTER

OLD GRID

DATA/CONTROL CENTER
FIREWALLS

OLD GRID

ACCESS CONTROL LISTS
STATELESS FIREWALL
STATEFUL FIREWALL
SERVICE-AWARE
ZONE-BASED
STATEFUL FIREWALL

SMART GRID

SMART GRID
SMART GRID COMMUNICATION NETWORK TRANSFORMATION
MAKING IT REAL

- INTRODUCTION OF NEW GRID APPS
- REDUCED TOTAL COST OF OWNERSHIP

PRESENT MODE OF OPERATIONS ASSESSMENT
GAP ANALYSIS
WIDE AREA NETWORK MODERNIZATION AND EXPANSION PLAN
FIELD AREA NETWORK EVOLUTION PLAN
TARGET ARCHITECTURE & HIGH-LEVEL NETWORK DESIGN
MIGRATION TO TARGET ARCHITECTURE INTERIM PHASE(S)
MIGRATION TO TARGET ARCHITECTURE FINAL

0.5 - 1 year
0.75 - 1.5 years
2 - 15 years
3 - x years
BELL LABS AND SMART GRID

NEXT-GENERATION
SMART GRID COMMUNICATIONS

- Pervasive Distributed Energy Resources
- Microgrids
- Market Retail Transactions

E-MOBILITY

Demand Management
ICT for Charging

SMART GRID NETWORK TRANSFORMATION

SMART GRID DATA ANALYTICS

DATA SOURCES

- Utility Operation
- Residential: Meter Data
- Government: Environmental, Safety
- Renewable Generation

UTILITY APPLICATIONS

- 1. Probability
- 2. Revenue Accounting
- 3. Pricing
- 4. Dispatch
- 5. Ancillary Services

COMMUNICATION NETWORKS FOR SMART GRIDS
Kenneth C. Bode
A. Jayant S. Sethi
Springer
THE FUTURE GRID RELIES UPON A
• HIGH-PERFORMANCE
• RELIABLE
• SECURE
• SCALABLE
• UBIQUITOUS
• COST-EFFECTIVE

COMMUNICATIONS NETWORK AND DATA INFRASTRUCTURE
www.alcatel-lucent.com
GRID APPLICATIONS

- System Protection
- SCADA (poll-response)
- SCADA (Distribution)
- Transformer Protection/Control
- Video
- AMI-Critical
- Voice
- Mobile Data
- PTT
- Synchrophasors
- System Protection

DIVERSE QoS, RELIABILITY REQUIREMENTS

Criticality:
- Most
- Least

Delay:
- 0.1s
- 0.2s
- 0.3s
- 0.4s
- 0.5s
- 0.6s
- 0.7s
- 0.8s
- 0.9s
- ≥1s