Enabling new utility business models with communications

Martin Hauske
We create the technology
to connect the world

Our businesses

Networks business
Providing end-to-end networking technologies, including ultra-broadband, IP and optical, cloud, the Internet of Things, software, analytics and services, we amplify business performance for our key customers.

Nokia Technologies
Licensing valuable Nokia intellectual property, including patents, technologies and the Nokia brand.

Our customer focus

Enterprise
We build mission-critical networks for webscale, transportation, energy and public sector, as well as for technical large enterprises in financial, retail, health, automotive and manufacturing industries.

Communications service providers
We build and operate agile, intelligent, secure and reliable networks for the world’s largest fixed, mobile, converged and cable operators.
We enable businesses to provide excellent customer experiences by introducing new services, operating hyper-efficiently and providing autonomous customer care.

Consumers
Through our licensing activities, we provide a premium and distinctively human technology brand, well loved by consumers and an evolving portfolio of audio, imaging and visual technologies to transform the consumer experience.

Our innovation engine

Nokia Bell Labs
Providing award winning research and development in support of a network vision 5-10 years into the future, we have been solving complex ICT challenges for over 90 years.

Nokia in numbers

1865
Year Nokia was founded

Espoo
Corporate headquarters in Finland

~103 000
Employees

~130
Countries of operation

€23.1 bn
Net sales*

9
Nobel Prizes

€4.9 bn
Annual R&D spend

© 2018 Nokia

* As of December 2017.

More information on Nokia is available on our corporate website Nokia.com. Performance information in financial reports is accessible within our website’s investors section (nokia.com/investors).
Disciplined execution for successful integration and transformation

- Acquired Motorola Solutions wireless networks
- Launched Networks transformation plan
- Sold Devices & Services
- Created Nokia Technologies
- Sold HERE
- Acquired Alcatel-Lucent
- Acquired Deepfield
- Acquired Comptel
- Acquired Unium
- Acquired SpaceTime Insight

- Pulp, Paper, Rubber, Early Bell System products, Mobile phones
- 2012
- 2014
- 2016
- 2018
We are capitalizing on the megatrends with our ‘rebalancing for growth’ strategy

1. Lead
   in high-performance end-to-end networks with communications service providers

2. Expand
   network sales to select vertical markets

3. Build
   a strong standalone software business

4. Create
   new business and licensing opportunities in the consumer ecosystem
Unrivalled track record of innovation

1300+ Patent applications (in 2017) 9 Nobel Prizes 3 Turing Prizes 2 Grammys 2 Emmys 1 Oscar
2018 Nobel Prize in Physics
Awarded to Nokia Bell Labs researcher, Arthur Ashkin

“Arthur was on a quest to improve human communications by understanding the limits of optical communications, and in the process, he created a technique that helped understand human life itself. Another classic Nokia Bell Labs tale, and one I anticipate will be repeated for decades to come, with the set of pioneering innovations we are currently working on that will define the 5G era and beyond.”

Marcus Weldon
Corporate Chief Technology Officer and President of Nokia Bell Labs
Our track record of continued investment & innovation in the Utility sector

<table>
<thead>
<tr>
<th>14</th>
<th>100%</th>
<th>200+</th>
<th>+12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of Industrial MPLS Experience</td>
<td>In-house development</td>
<td>Utility customers</td>
<td>Industry Awards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>+1000</th>
<th>24Bn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teleprotection Circuits in service</td>
<td>NOKIA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NERC/CIP</th>
<th>COMPLETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPLIANT GRID COMMS</td>
<td></td>
</tr>
<tr>
<td>END-TO-END SOLUTIONS &amp; SERVICES</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SDN</th>
<th>P-LTE</th>
<th>IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market leader</td>
<td>Market leader</td>
<td></td>
</tr>
</tbody>
</table>

Bell Labs

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### Nokia Power Utilities References

#### AMERICAS
- Aliant Energy, USA
- Allegheny Energy, USA
- AltaLink, Canada
- Amazonas Energia, Brazil
- BC Hydro, Canada
- Bristol Virginia Utilities, USA
- BTES, USA
- CFE, Mexico
- Chelan County Public Utility, USA
- CHESF, Brazil
- Dalton Utilities, USA
- Dayton Power and Light, USA
- EDELCA, Venezuela
- EPB, Chattanooga, USA
- First Energy, USA
- FPL Fibernet, USA
- Furnas, Brazil
- Grand River Dam Authority, USA
- Lafayette Utilities, USA
- MINET, USA
- Morristown Utility Commission, USA
- NPP, USA
- OG&E, USA
- Oncor, USA
- Paduah Power System, USA
- PDVSA, Venezuela
- PECO, USA
- PEPCO Holdings, USA
- We Energies, USA

#### EMEA
- ADWEA, Abu Dhabi
- AES Sonel, Cameroon
- AEW, Switzerland
- Alstom Power, Spain
- Areva, France
- BEWAG, Germany
- BKW FMB Energie, CH
- C Power NV, Belgium
- C4 ENERGI AV, Sweden
- CNR, France
- Creos, Luxembourg
- DATATEL, Russia
- DELTA, Netherlands
- DGA, France
- EDF, France
- EETC, Egypt
- ELIA, Belgium
- ENDESA, Spain
- Energy Ouest Suisse, CH
- EPAL, Portugal
- Eskom, South Africa
- Gas Natural Fenosa, Spain
- Hafslund, Netherlands
- IBERDROLA, Spain
- Israel Electric Corp, Israel
- Joököping Energi, Sweden
- KELAG, Austria
- NEK EAD, Bulgaria
- NRGi Fibernet, Denmark
- QUANTUM ICT, Belgium
- RTE, France
- Saudi Electric Company, Saudi Arabia
- Szazburg Stadtwerke, Austria

#### APAC
- Ausgrid, Australia
- CSG, China
- Electranet, Australia
- Energex, Australia
- Ergon Energy, Australia
- HEC, Hong Kong
- KEPCO, Korea
- MEA, Thailand
- PEA, Thailand
- PGCIL, India
- PLN, Indonesia
- SGCC, China
- TATA Power, India
- TEPCO, Japan
- TNB, Malaysia
- TPC, Taiwan
- TPDDL, India
- Transgrid, Australia
- Transpower, New Zealand

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30 years experience providing mission critical communications to 200+ utilities
Energy world is changing
Indicators of change

Renewable energy prices falling sharply

Surge in battery storage and microgrids

Demand disruptions impacting utility revenue models

• Energy conservation and demand management
• Building energy efficiency
• Distributed energy generation/off grids/micro grids
• Energy substitution (e.g., EVs, district heating)

- Origin Energy (Australia) adds 530 mw of renewable sets new benchmark for renewable ppa pricing – $60/mWh ($0.06/kWh)
- India recent bids as low as inr 1.58 ($0.022/kWh) for solar
New business model
Key reactions to industry changes
Grow revenues and build new capabilities paid for through cost savings

• **Grow revenues** with new services
• **Build capabilities** to manage distributed generation

• **Lower costs** by consolidating IT, OT, and external communication networks and IoT capabilities
Scenario analysis: New products and services can increase a utility’s share of wallet, despite declining commodity revenues

Potential Value of Bundling Smart Technologies – EV, HAN\(^1\) and Solar PV

### Example

<table>
<thead>
<tr>
<th>Commodity Impact</th>
<th>Commodity Revenue Impact</th>
<th>Services Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity Impact w/ EV</td>
<td>-140</td>
<td>110</td>
</tr>
<tr>
<td>Commodity Impact w/ HAN</td>
<td>-430</td>
<td>40</td>
</tr>
<tr>
<td>Commodity Impact w/ Customer PV</td>
<td>-100</td>
<td>500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Total Revenue Potential per Residential Customer ($ per Customer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity Impact (57%)</td>
</tr>
<tr>
<td>860</td>
</tr>
</tbody>
</table>

- New revenue stream from retail business
- Services revenues compensate for the negative commodity revenue impact

\(^1\) Home Area Networks
Source: Accenture analysis
"The new communications system will form the basis of our smart grid and ensure the network is always available to meet demand."

**Challenges**
- Bring new intelligence to its power transmission network
- Enhance reliability and efficiency
- Engineers remain connected while at substations

**Solutions**
- Consolidates vital services supporting remote monitoring, fault isolation and system safety and reliability onto a single IP/MPLS network
- IP/MPLS network meets differential protection and teleprotection requirements – tested less than 5 milliseconds latency across 104 km network of 11 routers with less than 200 microseconds jitter
- Advanced network monitoring and control tools

**Benefits**
- Enhance operational performance
- Save costs associated with managing multiple networks
Improved Asset Management – Oklahoma Gas & Electric, USA

2013 Edison award

“OG&E Electric Services: Our regulated electric utility serves 30,000 square miles in Oklahoma and western Arkansas”

Challenges
• Reduce peak demand
• Defer need to build generation plants
• Improve operational efficiency
• Strict timeline
• Complex project
• Limited resources

Solutions
• E2E IP/MPLS network
• P2P microwave backbone
• 3.65 GHz P2MP layer
• Full WiMAX and P2P microwave integration
• Tower/shelters/generators
• Advanced tools for monitoring and control

Benefits
• Reduction in customer demand by additional 2 percent/yr for next three years
• Savings of at least $22M over next year
• Demand response savings of 280 MW by 2017
• Defer fossil fuel generating investment to 2020
Improved Data Center and SD WAN – Leading Australian Utility

“We need to offer new services, connect to customers outside our existing network for deregulated services”

Challenges
• Offer New Services
• DC first, SD-WAN second

Base Scope
• VMware integration
• WBX L3 VTEP
• AWS cloud bursting
• Inter corp. branch traffic steering simplification through overlay techniques
• 2 DC integration via WBX and overlay
• AWS integration
• Underlay segments to overlay traffic steering with service chaining

Benefits
• Faster provisioning of IT services
• Provisioning of new energy services in deregulated business
New Services, New capabilities
-San Diego Gas & Electric, USA

“Every month a large number of customers are introducing Solar and we need to find a way to support that”

Challenges
• Reduction in demand
• Managing large amount of solar
• Supporting government and communities push for green power
• EV charging
• Innovative business model

Solutions
• Increase monitoring and control capability
• Increase number of endpoints to 200,000 end points (vs 3.6m customers)
• Looking at Private LTE

Benefits
• Improved integration of renewables
• Gain new revenue from service business – islands, green communities, etc.
• New business model – DSO
• Platform
Details of San Diego Gas & Electric - Market

Government Policy:

• The state is strongly committed to clean energy, even though the California Senate voted down its Bill 100, a proposed adoption of 100% renewables in California by 2045. In fact, a new report from the California Public Utilities Commission says California’s major utilities have already met or will all soon exceed the state’s 2020 renewable energy target of 33%, and will likely meet the 2030 target of 50% by 2020.

Sempra situation – high residential solar

• On average 43% of the electricity used at SDG&E is from renewable sources, which leads the nation. And on top of that, customers have another 800 megawatts or so of rooftop,” he says. (vs 4,781 megawatts (MW) system peak)
Load

Electric volumes (millions of kilowatt hours)

<table>
<thead>
<tr>
<th>Category</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>6,577</td>
<td>6,685</td>
<td>7,143</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>6,763</td>
<td>6,700</td>
<td>6,877</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>2,198</td>
<td>2,189</td>
<td>2,161</td>
<td></td>
</tr>
<tr>
<td>Street and highway lighting</td>
<td>79</td>
<td>75</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Direct access</td>
<td>3,394</td>
<td>3,515</td>
<td>3,652</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>19,011</td>
<td>19,164</td>
<td>19,916</td>
<td></td>
</tr>
</tbody>
</table>

March 28th-April 3rd, 2013-16 CAISO Hourly Net Load Curve

*from SEMPRA Annual Report 2017

**California Energy Commission – Renewable Energy Overview**
Losses
6.58% - down from 7.95% from 2009 - 2014

**California Energy Commission – Renewable Energy Overview**

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#### Estimated Electricity Losses from Delivery in California (2009-14)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Generation</td>
<td>71,957,335</td>
<td>78,907,645</td>
<td>82,486,064</td>
<td>105,260,204</td>
<td>96,993,553</td>
<td>85,123,706</td>
</tr>
<tr>
<td>Independent power producers</td>
<td>89,359,573</td>
<td>86,201,289</td>
<td>80,574,290</td>
<td>58,255,052</td>
<td>69,284,063</td>
<td>80,766,390</td>
</tr>
<tr>
<td>Electric utility</td>
<td>180,821,288</td>
<td>181,515,139</td>
<td>181,223,651</td>
<td>182,273,967</td>
<td>185,151,608</td>
<td>186,899,573</td>
</tr>
<tr>
<td>Combined heat and power, electric</td>
<td>2,603,360</td>
<td>2,763,572</td>
<td>2,994,426</td>
<td>2,890,377</td>
<td>2,300,064</td>
<td>2,243,754</td>
</tr>
<tr>
<td>Combined heat and power, industrial</td>
<td>15,184,308</td>
<td>15,384,308</td>
<td>15,624,308</td>
<td>15,894,308</td>
<td>16,124,308</td>
<td>16,354,308</td>
</tr>
<tr>
<td>Total net generation</td>
<td>198,807,622</td>
<td>200,077,119</td>
<td>199,918,567</td>
<td>200,804,842</td>
<td>204,123,996</td>
<td>204,776,132</td>
</tr>
<tr>
<td>Total international imports</td>
<td>12,249,204</td>
<td>12,412,327</td>
<td>12,624,927</td>
<td>12,892,345</td>
<td>13,170,924</td>
<td>13,412,279</td>
</tr>
<tr>
<td>Total supply</td>
<td>211,156,826</td>
<td>212,489,442</td>
<td>212,541,892</td>
<td>213,697,187</td>
<td>217,394,920</td>
<td>218,249,411</td>
</tr>
<tr>
<td>Estimated losses</td>
<td>13,587,284</td>
<td>14,248,546</td>
<td>14,288,272</td>
<td>14,908,719</td>
<td>15,972,948</td>
<td>16,524,105</td>
</tr>
<tr>
<td>Percent losses</td>
<td>6.88%</td>
<td>6.72%</td>
<td>6.50%</td>
<td>7.12%</td>
<td>7.92%</td>
<td>7.55%</td>
</tr>
</tbody>
</table>

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#### Electricity Losses Reported by California IOUs (2015)

<table>
<thead>
<tr>
<th></th>
<th>PG&amp;E</th>
<th>SCE</th>
<th>SDG&amp;E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales to Customers (MWh)</td>
<td>86,167,420</td>
<td>74,929,346</td>
<td>16,267,013</td>
<td>177,363,779</td>
</tr>
<tr>
<td>Sales for Resale (MWh)</td>
<td>1,813,063</td>
<td>4,031,926</td>
<td>16,865,020</td>
<td>22,710,549</td>
</tr>
<tr>
<td>Energy Used By Company (MWh)</td>
<td>NA</td>
<td>134,341</td>
<td>32,899</td>
<td>167,240</td>
</tr>
<tr>
<td>Total Sales (MWh)</td>
<td>87,981,023</td>
<td>78,961,272</td>
<td>33,132,033</td>
<td>200,074,328</td>
</tr>
<tr>
<td>Total Energy Losses (MWh)</td>
<td>7,615,777</td>
<td>3,360,028</td>
<td>1,544,260</td>
<td>12,520,065</td>
</tr>
<tr>
<td>Percent Electricity Loss</td>
<td>8.66%</td>
<td>4.26%</td>
<td>4.66%</td>
<td>6.26%</td>
</tr>
</tbody>
</table>

**© Nokia 2016**
Load Factor
Shift to afternoon peak except for June – relatively mild climate

**California Energy Commission – Renewable Energy Overview**
Sempra policy influence – shift to DSO, storage,

- In 2016, the California Public Utility Commission directed Southern California investor-owned electric utilities to fast-track energy storage options to enhance regional energy reliability.
- Shift peak pricing to 4pm – outside solar main time
- Shift to renewables business
- EV - File for V2G approval (Application of San Diego Gas & Electric Company (U 902-E) for Approval of Senate Bill 350 Transportation Electrification Proposals Regarding Medium and Heavy-Duty Electric Vehicles and a Vehicle-to-Grid Pilot)
How to improve reliability in the new world of distributed generation – Californian Utility

“The utility is in the process of upgrading their substation infrastructure in an effort to improve grid reliability. This include a total substation redesign (Relays, RTUs, SCADA and telecommunication (NOKIA) equipment).”

Solution highlights:

• Long term TDM to IP migration but short term need for legacy TDM interfaces in a packet environment.
• IP/MPLS is the technology of choice
• Around 400 Transmission substations involved, 1000 routers, 800 switches.
• Nokia solution selected after multiple rounds of lab and field testing.
• Heavy cyber security requirements, NSP, 7705 and 7210 had to go through special testing - third party security company.
• NSP/CPAM/Service Portal Express with north bound integration with their MoM (SPLUNK)
• Project broken in multiple phases. Currently implementing Phase 1, 250 routers, 200 switches.

Scope includes

• Hardware/Software
• Network Design and Engineering, Installation supervision (unions), Staging
• Two Full time Resident Network Engineer, Project Manager, Nokia’s Remote Network Operation Center (NOC) involvement
• Training and Certification classes for products involved, Full Maintenance, Remote Tech Support
• Software Subscription Plan
• Extended Warranty, Advanced Exchange Program
Aquarius Generator Capabilities

• Modular unit, small form factor, few moving parts.
• Monitored and managed remotely by software connected to sensors.
• Extensive advanced diagnostics data and remote control capability, enabling real-time analysis of performance, optimisation, identification of potential failures as well as remote resolution.
• Cluster design with load balancing/redundancy capabilities, providing higher SLAs and flexibility to meet various energy load requirements.
• Generator analytical models developed through extensive telemetry data significantly improving predictability of engine performance, failure and optimization of energy consumption.
Nokia’s – Global NOC
Global Monitoring and Management Service

Reliable operations
• Self monitoring
• Operations segmented based on work scope
• Predefined templates

Security
• High availability
• Forensic analysis
• Attack resistant
• Centralized user management

Deployment
• Automated bulk software updates (firmware and configuration)

Analyzing
• Advanced visualization
• Map views and real-time dashboards

Configuration
• Consistent device configurations based on auditing and policy enforcements

Trouble shooting
• Alarm correlations
• Fault management
• Trouble ticketing system
Aquarius Smart Energy Management System
High Level Requirements

• Centralized Energy Management System for all Aquarius generator installations.
• Offered as a service to clients with an annual maintenance & support subscription fee on a per generator unit basis.
• Remote, near real-time (24x7x365) Centralized Monitoring and Management as per agreed SLA’s:
  – Service Desk
  – Alarm Monitoring
  – Fault Investigation and Management
    • 1st Level (Nokia)
    • 2nd Level escalation (Aquarius)
    • 3rd Level site support (client field support resource)
  – Change Management
  – Generator Data Collection & Storage
  – Generator Device Management (e.g. device discovery, firmware & software updates)
  – Security Management (e.g. Anomaly detection, User management, software signing)
  – Generator Remote Management
    • Northbound Interface to Aquarius software system
    • Configuration (remote settings)
    • Cluster Optimization
    • Predictive / Preventative Maintenance
Creating with University of Strathclyde a resource for utilities to accelerate their innovation and reduce risk while transforming to new business models
BHP Project Insights

• BHP Minerals Australia goals:
  – Increase Safety
  – Increase Tonnage
  – Reduce Operational costs

• BHP Current situation:
  – “In pit” Wireless end of life and unreliable
  – Rail corridor becoming a bottleneck
  – Lost production on Truck Autonomy fleet
  – Unable to expand fleet with reliability

• BHP process:
  – Trial with Private LTE 3 years ago
  – RFI, RFT – Nokia successful
  – Moved to implementation phase

• What made the solution successful?
  – Reliable In Pit Coverage with increase bandwidth and Quality of Service
  – Met BHP all goals by increasing Autonomous mine fleet and increases Rail capacity, reduces manpower at site
  – Management of delivery process
    • Equipment testing prior to delivery
    • Lab Testing
    • Management of technology upgrade and change over
    • Use of experienced resources in mining environment
    • Operational readiness program for BHP Staff
    • Training
    • Managed Services - to decrease risk

BHP as we lay the foundations for fully integrated and highly automated operations by 2025.

The productivity benefits of the autonomous haulage fleet at Jimblebar has helped reduced costs by around 20 per cent. Most importantly, our autonomous trucks and drills shield employees from dangerous situations.
BHP Current state

- Trailer x 100
  - Unreliable
  - High maint
  - End of life

Rail Bottleneck
BHP Future state

- Increased Rail Usage via reduced separation
- Macro sites x 12
  - High availability
  - Higher bandwidth
  - Increase tonnage
Oil and Gas require a transformation of their operations

- Connect assets & people to improve efficiency & awareness
- New era of automation (remote operation, robotics)
- Data analytics and sharing
Equatorial Guinea - ExxonMobil
General Requirement

• **Wireless Connectivity Required**
  - Offshore Assets:
    - Production Platform “Jade”
    - Fixed FPSO (Zaphiro)
    - Rotating FPSO (Serpentina)
    - Visiting Vessels
  - Offshore Units have high speed point to point microwave.

• **Coverage Radius Requested**
  - Minimum 20 km radius from platform
  - Topside coverage only for data CPE’s

• **Future Enhancement**
  - Below decks coverage
  - MC-PTT
Future Oil & Gas Digital Transformation
Beyond Connectivity for Challenging Environments

Connected Assets and Workers
Remote sites, Offshore sites, Temporary sites, Construction sites

IloT for automation
Digital PPE/Wearables
Processing plants, Accommodation camp, Pipeline Main Stations

Connected Facilities

Robotics & Drones
HQ/DC
Refineries, Petrochemical plants
How the Nokia AR Training works

1. Put on HoloLens Headset
2. Look at object and scan
3. Interact in Augmented Reality
Creating high-performance, mission-critical networks
On land, air, sea and soon to the Moon