# スマート・グリッドにおける携帯電話網の新しい役割

クアルコムジャパン
Business Development

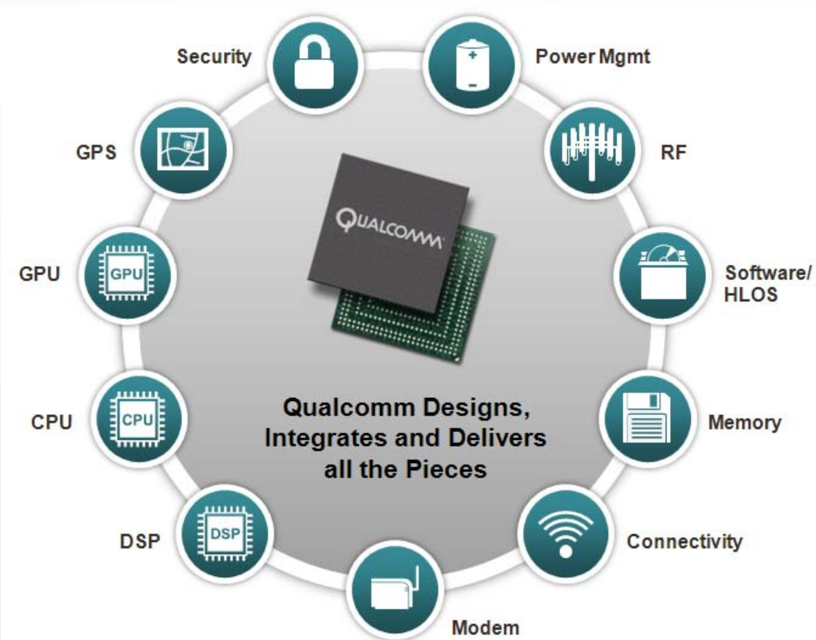
# Qualcomm Is a World Leader in Next-generation Communications Technologies

- 25+ years of innovation in mobile
- Focus on making customers successful
- Helping lead the evolution of smart connected devices
- World's largest fabless semiconductor company, #1 in wireless, delivery of 1B chips per year
- FY10 Revenues $10.99B, Fortune 500, 18,000 employees

Institutional Investor
2011 All-America Executive Team

Source: iSuppli for Dec. 2010

# Qualcommバリューチェーン




チップセット

モジュール化

機器組み込み

公共事業企業

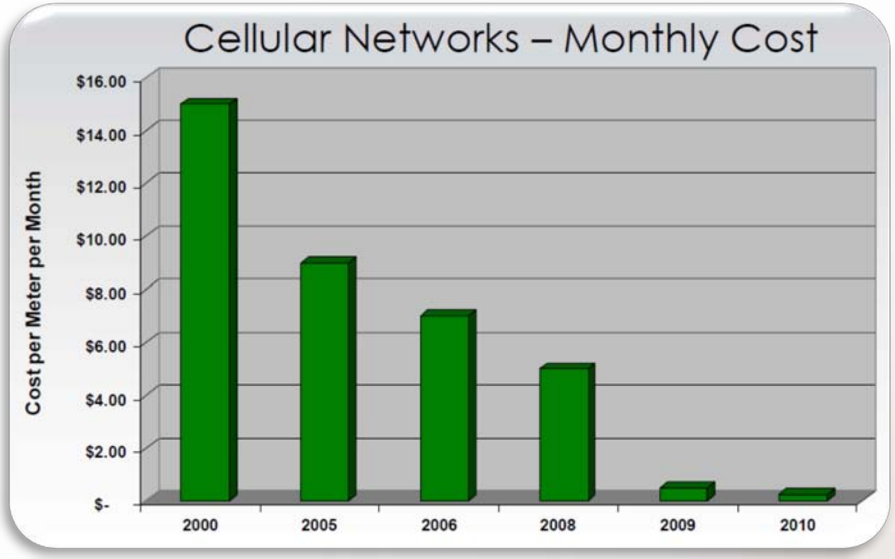
# 本プレゼンテーションでの主要事項

- 携帯電話網の技術属性はスマート・グリッドに適切
- マルチモード　–　サービスエリア、信頼度、並びに柔軟性
- 今日の携帯電話網での稼動事例

# 属性 #1: コスト

携帯電話網利用コストは、もはやスマート・グリッドの主な障壁ではない

- 時代経過と共に接続コストの劇的な縮小
- 手頃なハードウェア価格
- 高度な競争環境




出展: SmartSynch

# 属性 #2: サービスエリアと利用性

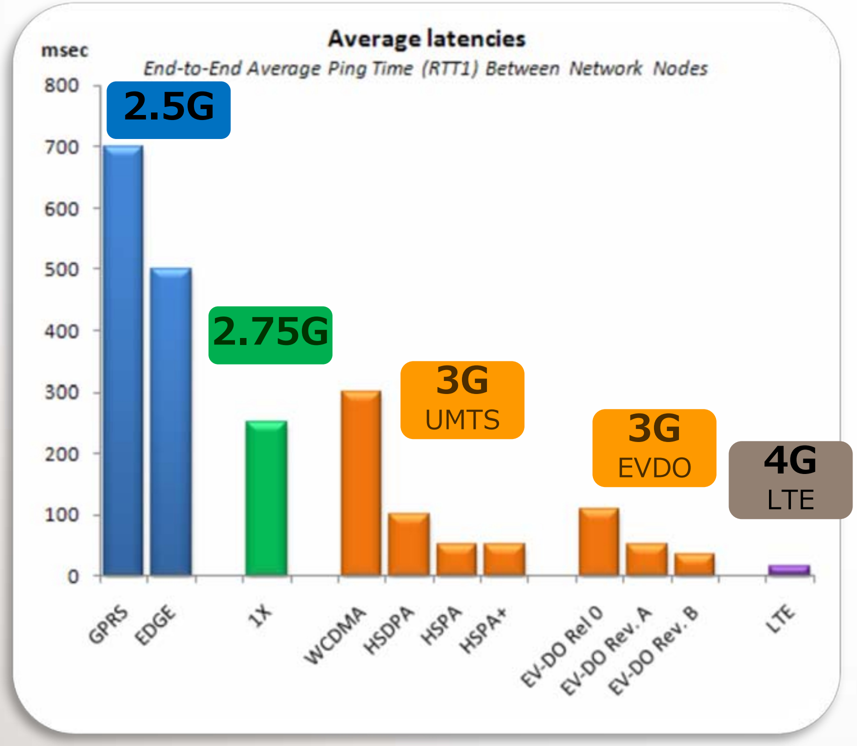
携帯電話網は広く利用可能

- 迅速な導入が可能
- 場所と規模の観点から非常に柔軟
- 事業者は、継続的にネットワーク拡張に投資


* 総務省データ　平成19年3月末現在

# 属性 #3: リアルタイム通信

高度なスマート・グリッドアプリケーションへの統合は用意されている




End-to-End Average Ping Time (RTT1) Between Network Nodes Performance is based on empirical measurements from commercially available systems.

Source: CDMA Development Group; "Mobile Broadband Comparison"; March 2008

| ISO/RTO PEV Products | Latency (delays tolerated) | | |
|---|---|---|---|
| | Aggregator to ISO/RTO | PEV / ESVE to Aggregator | Aggregator to PEV / ESVE |
| Energy - real-time | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| Energy - day-ahead | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| Enhanced Aggregation | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| Capacity | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| Reserves | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| DR as Regulation | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |
| Retail Dynamic Pricing Signal | Less than 1 scan rate | Less than 1 scan rate | Less than 2 seconds |

Source: ISO/RTO Council; "Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems" March 2010

# 属性 #4: 標準準拠

携帯電話の技術は確立している標準母体によって規定

- 3rd Generation Partnership Project (3GPP)
  - GSM, UMTS, LTE

- 3rd Generation Partnership Project 2 (3GPP2)
  - 1xRTT, EV-DO (Rev. 0 / A / B)

仕様書は www.3GPP.org 並びに www.3GPP2.org

# 属性 #5: セキュリティー と信頼性

証明され統合された技術

- 携帯電話システムは、消費者、企業および政府にセキュリティーの高いソリューションを提供

- 広く認知され、深く分析された強固なプロトコルは長年展開されている

各種評価に適合:

- スケール(40 ~ 50億の加入者)
- 時間 (数十年の運営)
- ユーザー (金融、政府、企業)

# 何故エンド・ツー・エンドのセキュリティーが必要

- スマート・グリッド通信の導入は必ず弾力的であるべき
- 成熟し深く分析された対策がインフラの保護にとって重要
- 例えば携帯電話網の様なエンド・ツー・エンド・システムは、IPセキュリティを促進するセキュリティー鍵配信のシンプルでより強固なセキュリティーモデルを提供
- 公開鍵インフラ(PKI)でサポートされたIPSECは、エネルギー企業が端末装置を仮想プライベート・ネットワーク(VPN)に適応可能
- 企業、政府、および金融は、よく裏付けられたシステムで運用している
- エンド・ツー・エンド・セキュリティは、重要基幹システムで要求されるプライバシー、データ保全性および機密性を備える

Technology suppliers:

ambient ECHELON SmartSynch

# 事例: Duke Energy

3Gの携帯電話技術をコミュニケーション・プラットフォームのバックボーンとして

- 3Gコミュニケーション・ノード
  - 配電変圧器に設置
  - 何千ものノードが既に展開済み
  - 将来のマルチモード機能
- 短距離無線接続と
  - WiFi と PLC
  - Home Area Networks と AMIを可能に
  - ノード - ノード間通信を可能に
- 種々のアプリケーションをサポート
  - オートメーション分配
  - スマートメータリング
  - プラグ・イン電気自動車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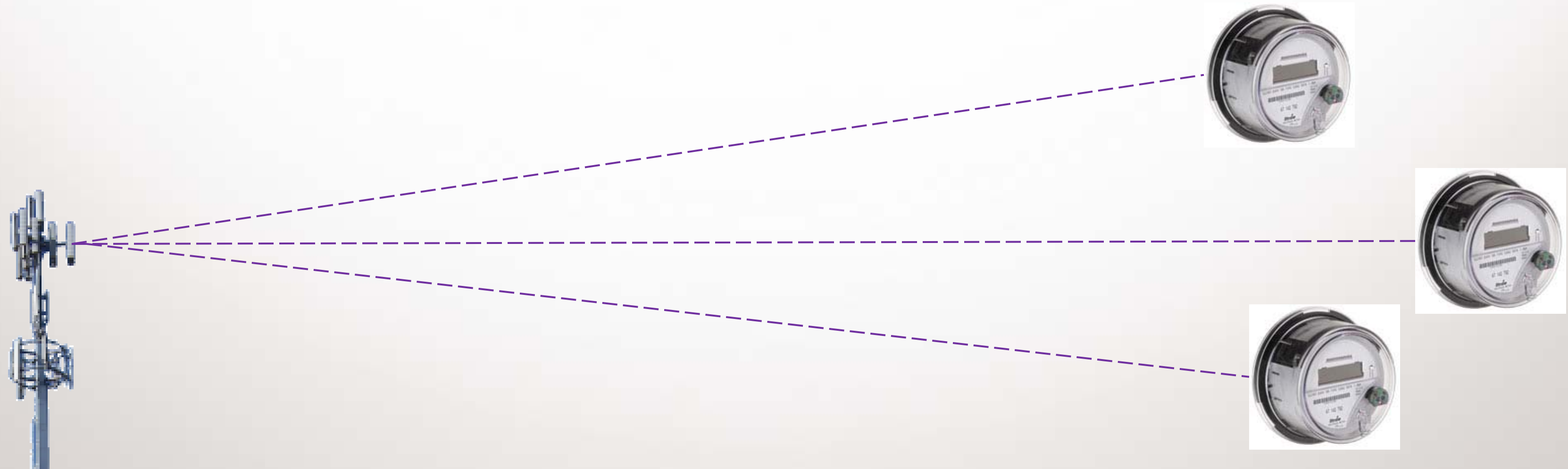
# 事例: コンスーマー・エネルギー

Technology supplier:
SmartSynch

## 携帯電話の技術はスマートメーターへ

- 180万のスマートメーター展開
  - 各メーターに携帯電話網接続
  - 新たなネットワークインフラは不必要
  - SmartSynchの以前のパイロット試験では非常に高い読取率を証明



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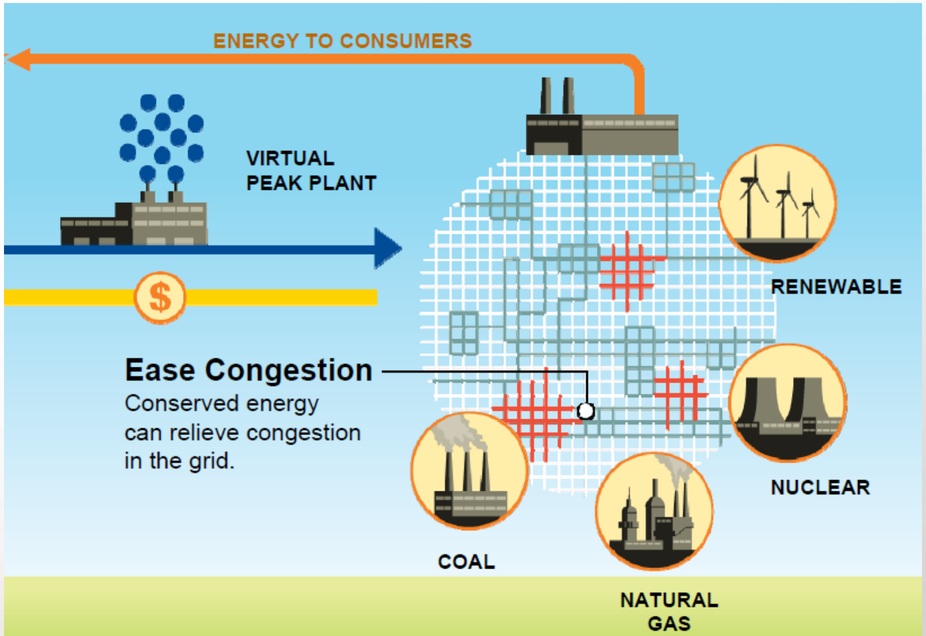
# 事例: CPS Energy

Technology supplier:

ホーム・エネルギー管理はグリッド・リソースに変換

- ユーティリティ駆動の居住向けデマンド管理システム(140,000ユニット)
- エネルギー資源/容量として動作(250MWの仮想ピーク・発電)
- 3Gは低い接続コストおよびリアルタイム通信を可能に

+

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# 事例: EV Project

プラグイン電気自動車へのスマート充電

Technology supplier:

- D.O.E. 認可
  - ~15,000 充電器
  - 16 都市(6 州 + Washington D.C.)
- 携帯電話技術が各々の充電器に
- 将来の充電インフラストラクチャー機能
  - 充電ステーション・オペレーションの管理
  - 使用データの転送
  - ファームウェアーアップデートのダウンロード
  - リアル・タイムで電気自動車のドライバーへ提供性を通知


Trademarks and trade names and logos are those of its respective owners.

# Learn More

## Additional resources

- **DISTRIBU**TECH – 1/24-26/2012 サンアントニオ、テキサス州
  - http://www.distributech.com

- ‘Cellular and the Smart Grid: A Brand New Day’
  - IDC Energy Insights発行のWhite paper

- www.qualcomm.com/SmartEnergy

ありがとうございました

# 3G Cellular Technology for Smart Grid Communications

The topic of this presentation is comparing cellular with other communication technologies. The focus is on Smart Grid applications.

## Study Approach

1. Collect and analyze Smart Grid communication use cases
   a) Identify key Smart Grid communication use cases
   b) Research use case characteristics and requirements based on information from OpenSG, EPRI, and utility companies.
   c) Derive Smart Grid communication network technical requirements (including capacity, performance, coverage, and reliability) based on individual use case requirements.
2. Evaluate Smart Grid Communication technologies:
   a) Analyze the key characteristics of potential Smart Grid Communication technologies, including 3G cellular, GPRS, RF mesh, and PLC.
   b) Compare the technologies against a number of key selection considerations
   c) Compare the technologies against the identified technical requirements.
   d) Evaluate the total cost of ownership of the technologies for Smart Grid applications.
3. Review with Utilities:
   a) Review results with a diverse pool of utilities - IOU & Municipal Utilities in multiple geographies, and at different phases of Smart Grid deployment




**Study Approach**

We have performed a study to analyze Smart Grid Communication requirements and to evaluate the suitability of cellular and other technologies for Smart Grid applications. Our approach consists of the three steps below:

1. We first identified Smart Grid Communication use cases based on information from reputable sources. The network requirements are then derived from these use cases.

2. In the next step, we evaluated potential Smart Grid Communication technologies, including 3G cellular, GPRS, RF Mesh, and Power Line Communication (PLC). We compared their technical capabilities against the technical requirements and some key consideration factors, and then analyzed their total cost of ownership.

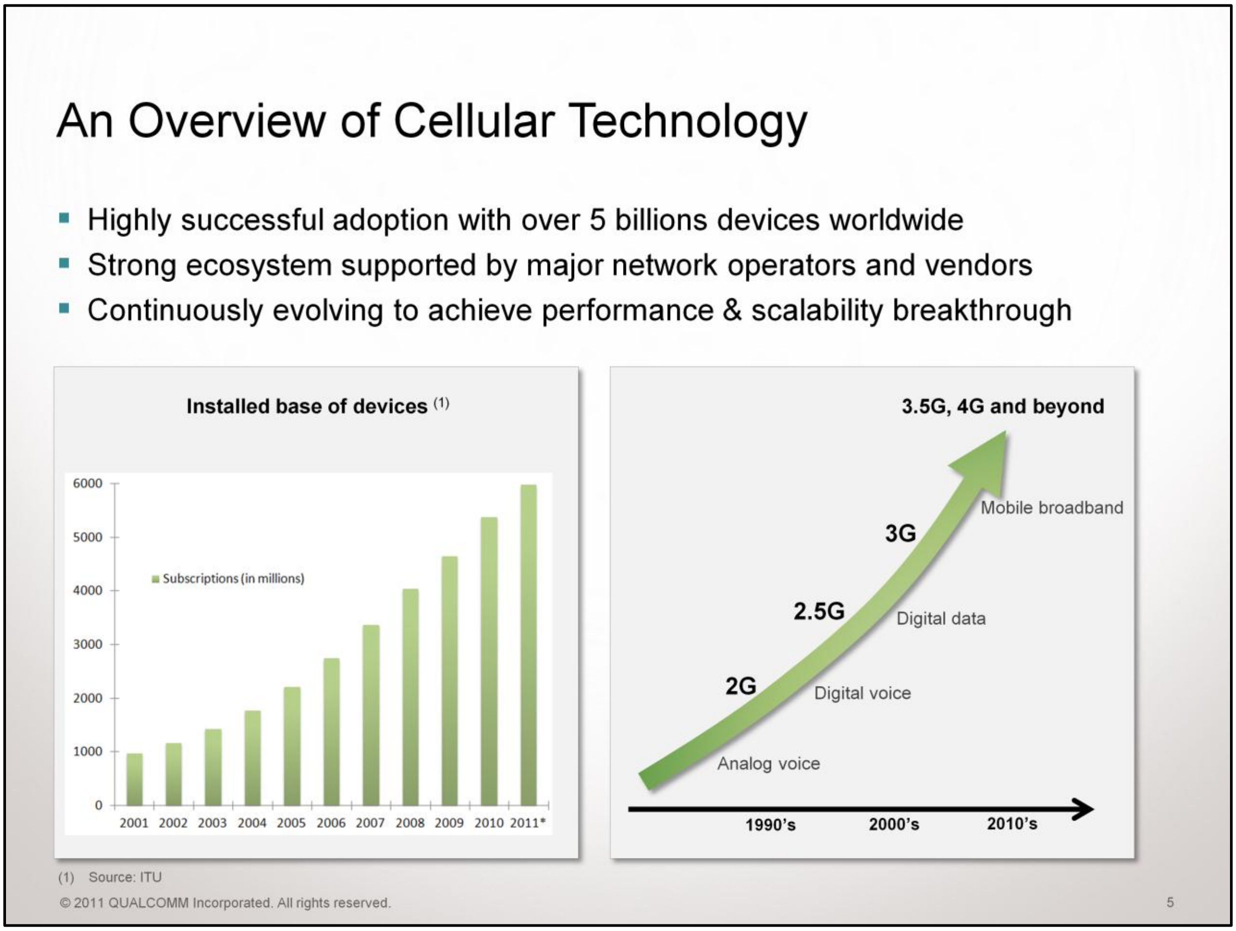
3. As part of the study, we reviewed our results with utilities companies in multiple geographical regions. We then revised the results based on their feedbacks.

# 3G Cellular for Smart Grid Communications

# Key points from this presentation

***3G Networks provide an advanced and cost-effective solution for Smart Grid Communications***

- Strong ecosystem enables cost-effective deployment & operation.
- Mature technology supported by global standards.
- Highly reliable services with ubiquitous coverage.
- Strong commitments from operators and vendors on Smart Grid applications.

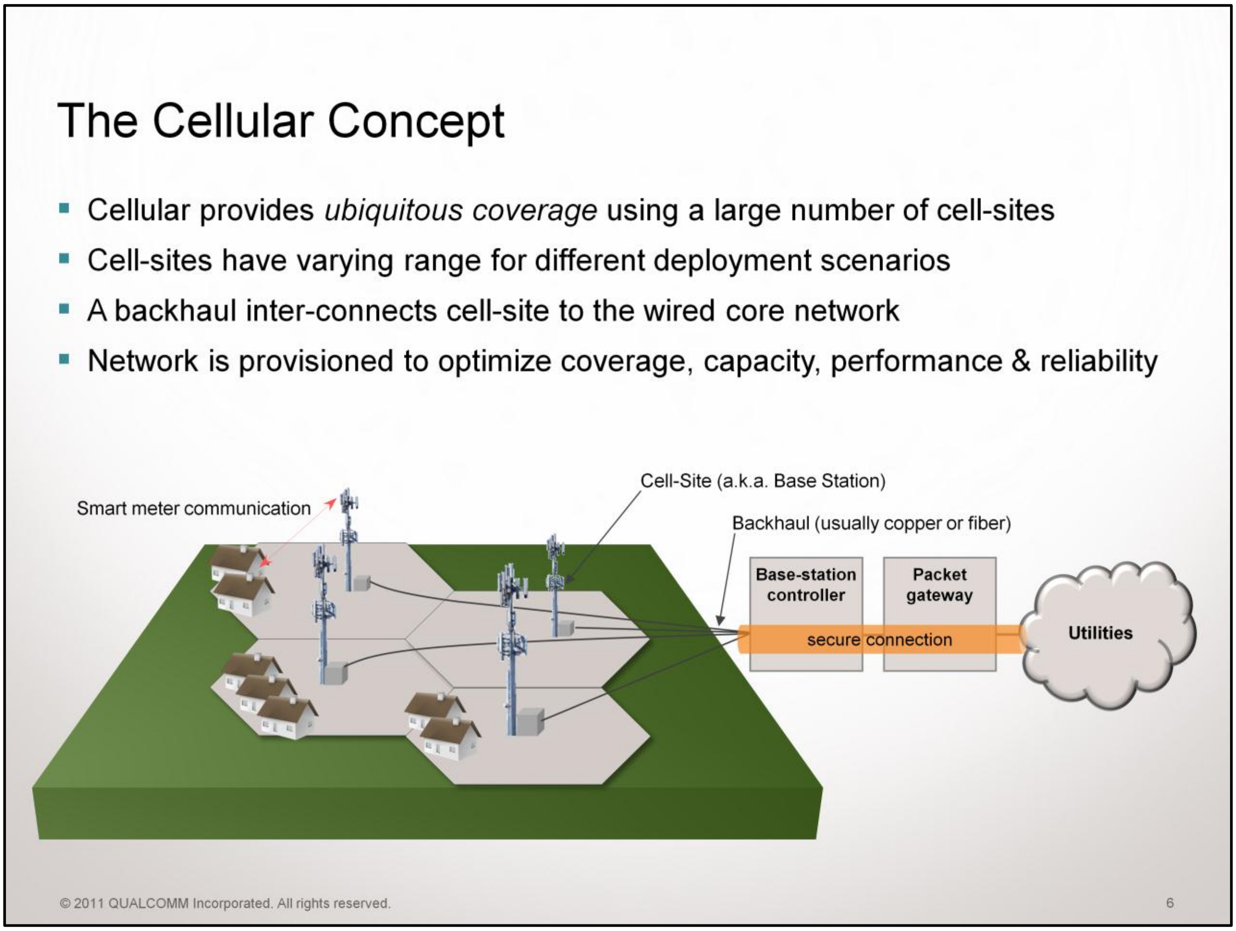



## An Overview of Cellular Technology

Today, cellular is one of the most successful communication platform even developed. Cellular has highly successful adoption with over 5 billions devices worldwide. The large ecosystem size leads to the development of a strong ecosystem, that is supported by chip developers, device makers, network infrastructure vendors, and services providers.

Throughout the history of cellular, it has been constantly evolving to achieve performance and scalability breakthrough. The chart illustrates the different generations of cellular network:

- First Generation (1G) (not shown in the chart) – Analog cellular systems supporting handoffs. Analog networks primarily supported voice users.
- Second Generation (2G) – Introduced digital modulation techniques and vocoders for voice data compression. The digital nature of 2G technology enabled low-to-medium data rates (approximately equivalent to dial-up speeds) for wireless data.
- Third Generation (3G) – Like 2G systems, 3G systems also employ digital techniques and vocoders, and offer higher data rates and increased capacity.
- Fourth Generation (4G) – Future networks with higher data rates, lower latency (delay), and better mobility.

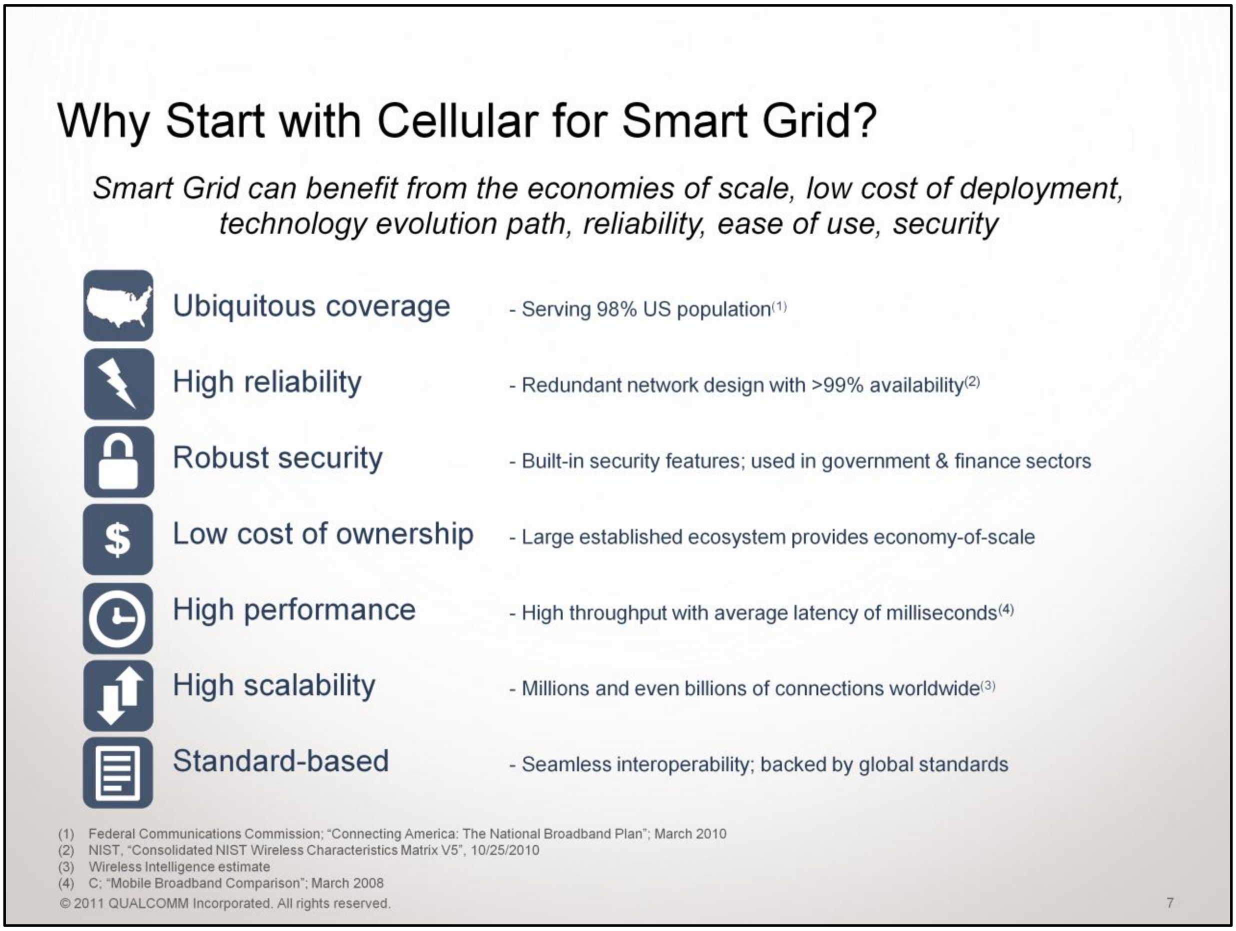



**The Cellular Concept**

A breakthrough introduced in First Generation (1G) mobile wireless technology was the development of the cellular concept. A cellular system consists of a network of Base Stations, or cell sites. Cell sites have antennas, and one or more sets of radios, each known as a Base Transceiver Station (BTS). Each cell site has a coverage area that is determined by many parameters, including spectrum used, antenna height, antenna patterns, transmit power, etc.

As a cellular user travels, he or she is handed off from one Base Station to another along the network. Although the basic concept is simple, the actual implementation of cellular technology involves sophisticated switching and call processing technology that was not commercially feasible until the early 1980s.

The cell sites are connected to the core network through secured backhauls. The core network consists of base station controllers, packet gateways, and a secured transport network that inter-connect the network nodes together.

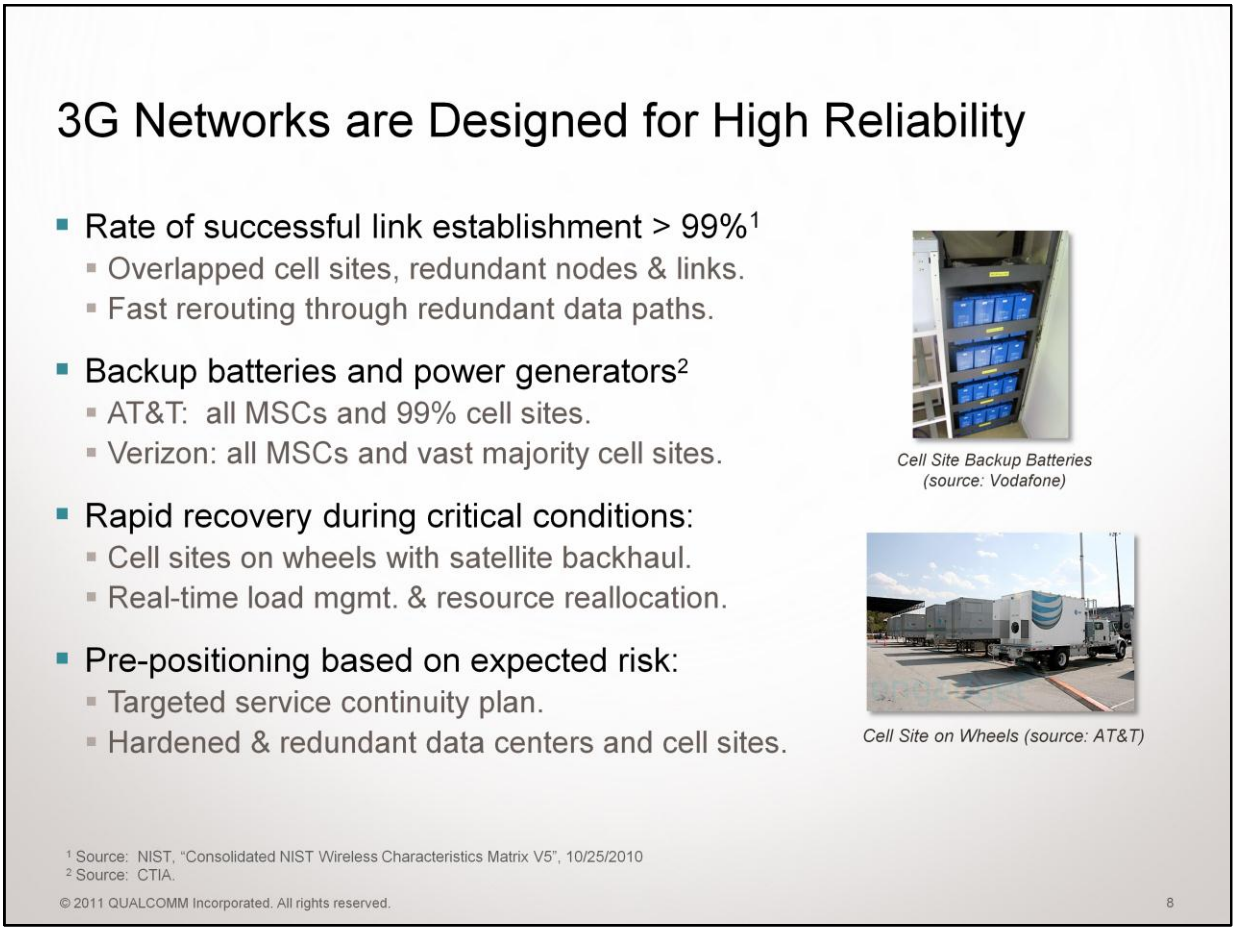



**Why Start with Cellular for Smart Grid?**

Smart Grid can benefit from several key advantages of cellular technologies:

1. High performance: cellular technology is constantly evolving. Today, data rate in excess of 2 Mbps and latency in milliseconds are typically available.
2. High reliability: Operators have deployed redundant data transport and network components, backup batteries, and power generators to ensure uninterrupted operations. The availability of cellular networks is rated at 99%.
3. Ubiquitous coverage: cellular networks are serving more than 98% of US population today. Coverage can be further extended, for example by low-cost small cells.
4. Robust security: Cellular networks have built-in security features, including encryption and authentication. Additional application layer security mechanisms can be use to meet particular use case requirements.
5. Low cost of ownership: cellular has a large ecosystem including chip developers, device makers, infrastructure vendors, and service providers. This ensures low device, deployment, and operation costs.
6. High scalability: Cellular network can support millions of devices. It has been demonstrated that it can scale to support fast device and traffic growth.
7. Standards based: cellular technologies are backed by global standards. Seamless interoperability among devices and networks is ensured.

With more than 5 billion connections worldwide, cellular is the most successful communication platform ever developed. Smart Grid can benefit from the strong ecosystem that has been put in place by the mobile industry.




**3G networks are Designed for High Reliability**

Cellular networks are designed with reliability and high availability as basic requirements.

- Modern network equipment incorporates redundancy features to ensure continued operation even when there is component failure, transport networks are designed with multiple redundant data paths and with fast rerouting when failure occurs, cell sites have overlapped coverage, etc.

- Cellular operators, like AT&T and Verizon, are deploying backup battery and power generators at the cell sites and data centers to sure services will not be interrupted during power outages.

- On top of the above, the structure of data centers and cell sites are hardened based on the expected risk. Transportable cell sites, such as cell site on wheels with satellite backhaul, are on standby to minimize network down time even in disaster situations.

# 3G Provides High Capacity & Ubiquitous Coverage

- Cover 98% US population[1]:
  - Further coverage extension through low-cost small-cells
- High capacity and data rate:
  - Support millions of meters in the utility's territory
  - Push large firmware updates to smart meters
- Continued service in disasters or special events:
  - Augment capacity & coverage by transportable cell sites
  - Prioritized access to maintain critical services

*3G network is provisioned to support high traffic load. E.g. during sport events.*

***Smart meters support more flexible antenna configuration to take full advantage of 3G's capabilities***

[1] Source: Source: Federal Communications Commission "Connecting America: The National Broadband Plan" (rel. Mar. 16, 2010)





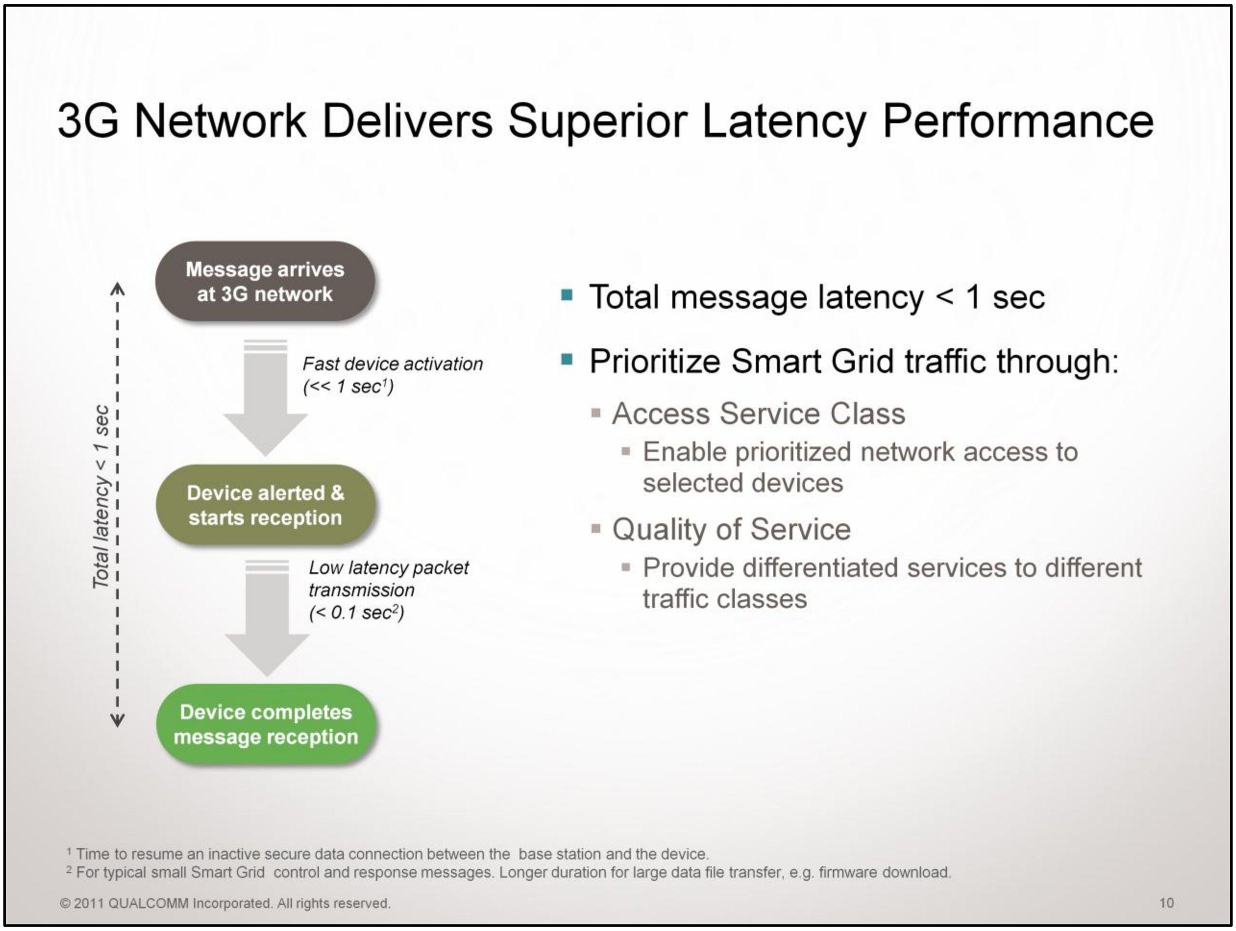
**3G Provides High capacity and Ubiquitous Coverage**

- Today's 3G networks support millions of users and many of them using Smart Phones that generate large volume of data traffic. High network capacity is thus a critical requirement. The cellular industry has been working continually to enhance radio and network capacity and data rate to address user demands.  These efforts and the resulting network capacity improvements make it possible for cellular networks to support large number of smart meters in a small area. Cellular can support many of the smart grid use cases. For example, cellular network is able to push large firmware images to the smart meters.

- Today's cellular networks have large footprints covering 98% of the US population. When necessary, additional solutions such as small cells, can be used to further extend coverage. This ensures connectivity can be provided to all smart meters and distribution network devices in the utility's service area.

- During disasters or special events when the cellular network is under unexpected high traffic load, transportable cell site can be used to augment capacity and coverage. Priority access mechanism can also be enabled to ensure fast response time for critical services.

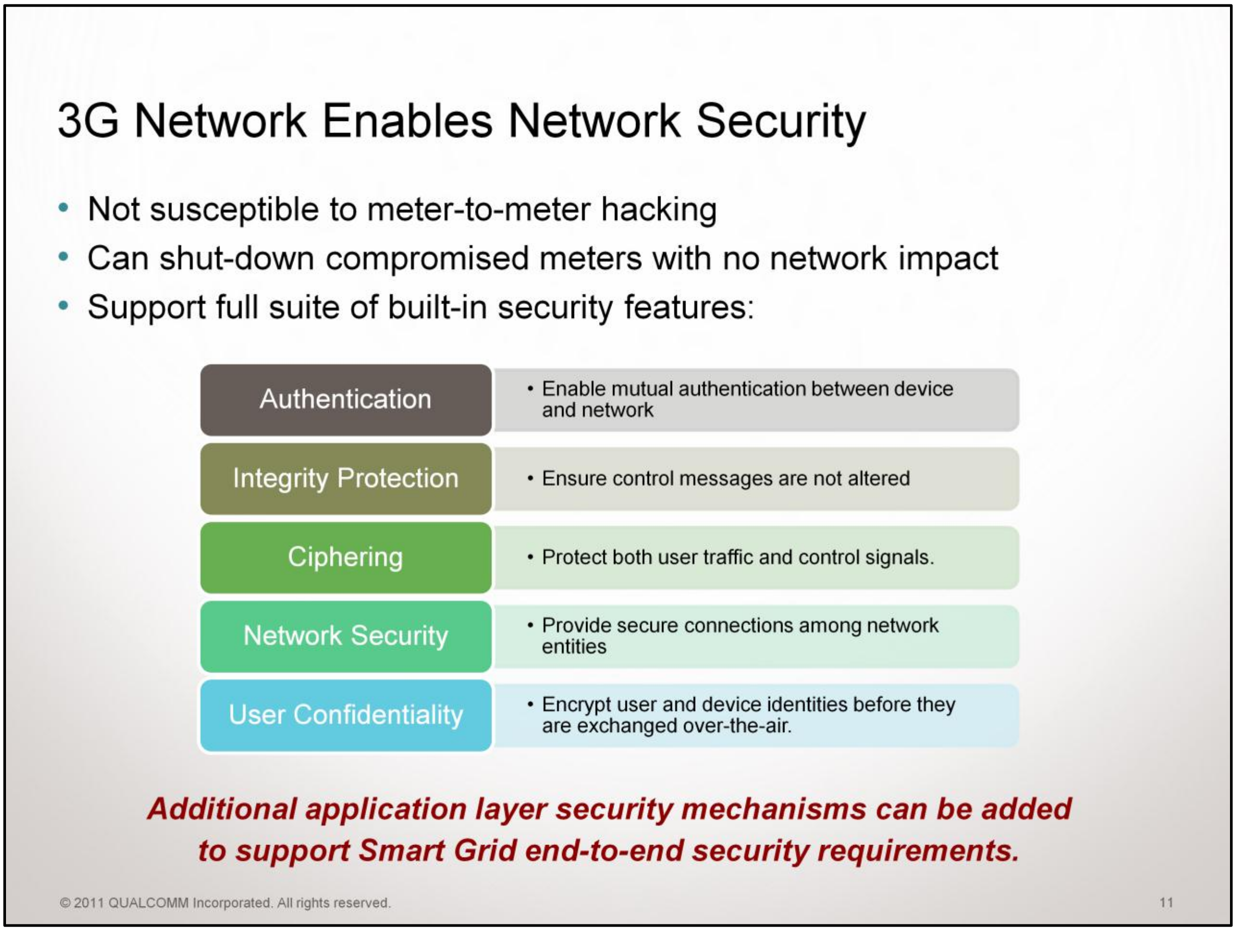
- Finally, smart meters have larger form-factors (compared to mobile phones), they are installed in a fixed location with flexible antenna placements. All these enable smart meters to take full advantage of 3G's capability to achieve superior coverage and performance compared to mobile phones.




**3G network Delivers Superior Latency Performance**

- Latency can be spilt into end-to-end call-setup latency (without IP context) or latency from Dormant/Inactive state (with IP context).
  - Not having an IP context normally occurs the first time a device accesses the system, or after long periods of no activity. This usually requires the device to setup the radio session, setup a packet data session, obtain an IP address and then send the related data. All of this takes much longer than 1sec.
  - Setting up a call from a state with an existing IP context only requires the setup of the radio session and is much faster, the device maintains its IP address. This time is much less than 1sec.

- There are associated timers and parameters in the network that can adjust the time allowed to maintain an IP context. There are also features in the network that allow faster call-setup, QoS and prioritization of traffic.
  - Data Over Signaling (DOS) Protocol allowing the Access Terminal (AT) and AN to receive and transmit data without requiring a dedicated traffic channel.
  - The Enhanced Idle State protocol in 1xEV-DO Rev. A defines a mechanism to negotiate shorter Paging Cycles
  - Bundling of messages
  - Future enhancements to allow PPP persistence
  - Enhanced FACH state to allow devices to maintain Inactive state for longer periods of time



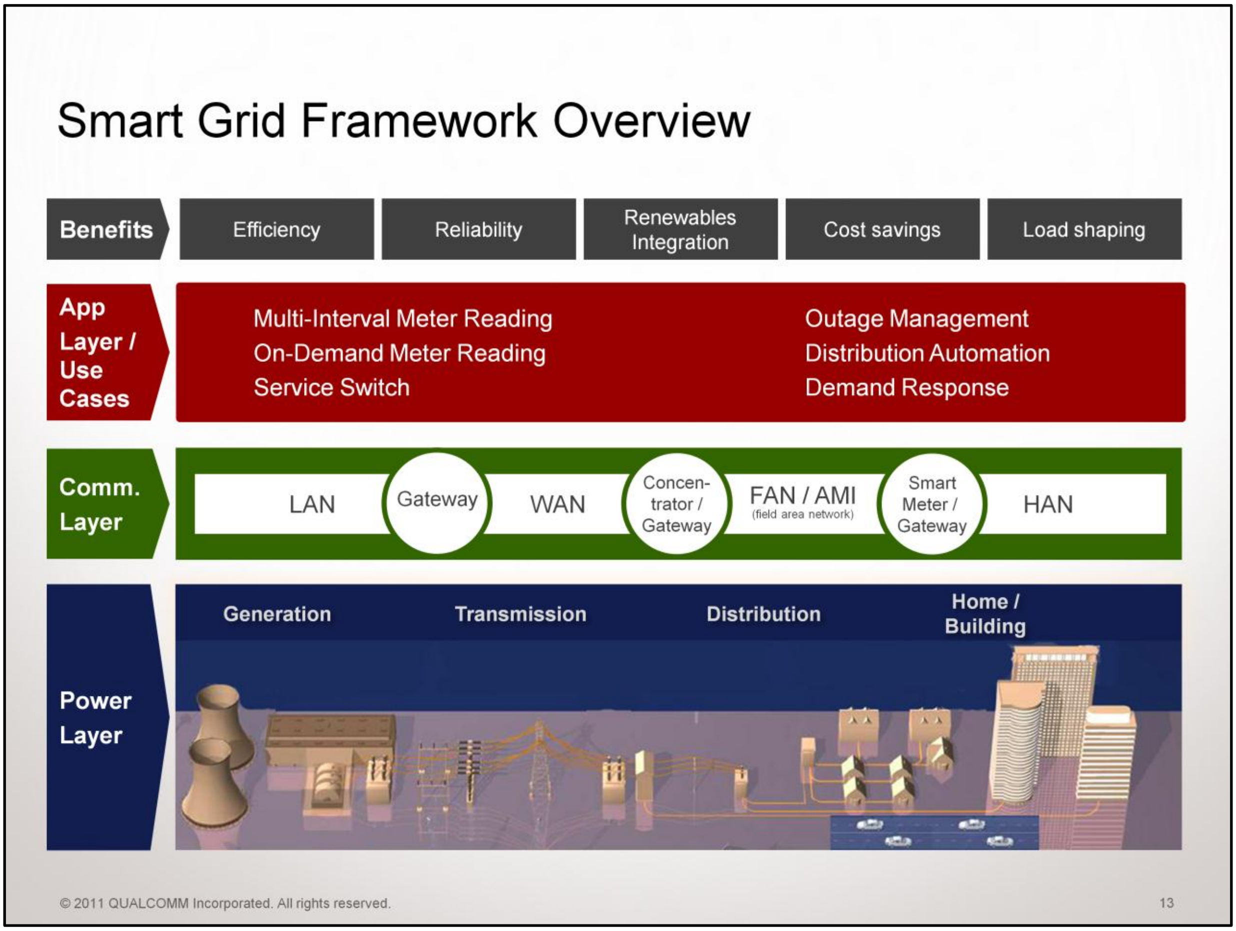

**3G network Enables network Security**

- Cellular network does not make use of device-to-device communication and is not susceptible to meter-to-meter hacking. In effect, individual smart meter can be completely shut down without any impact to the network.

- In addition, cellular networks support a full suite of security features and protocols, including authentication, integrity protection, ciphering, network security, and user confidentiality.

- The available data rate of cellular also enables the support of additional application layer security mechanisms to meet particular smart grid use case’s security requirements.

# Smart Grid Use Cases and Network Requirements



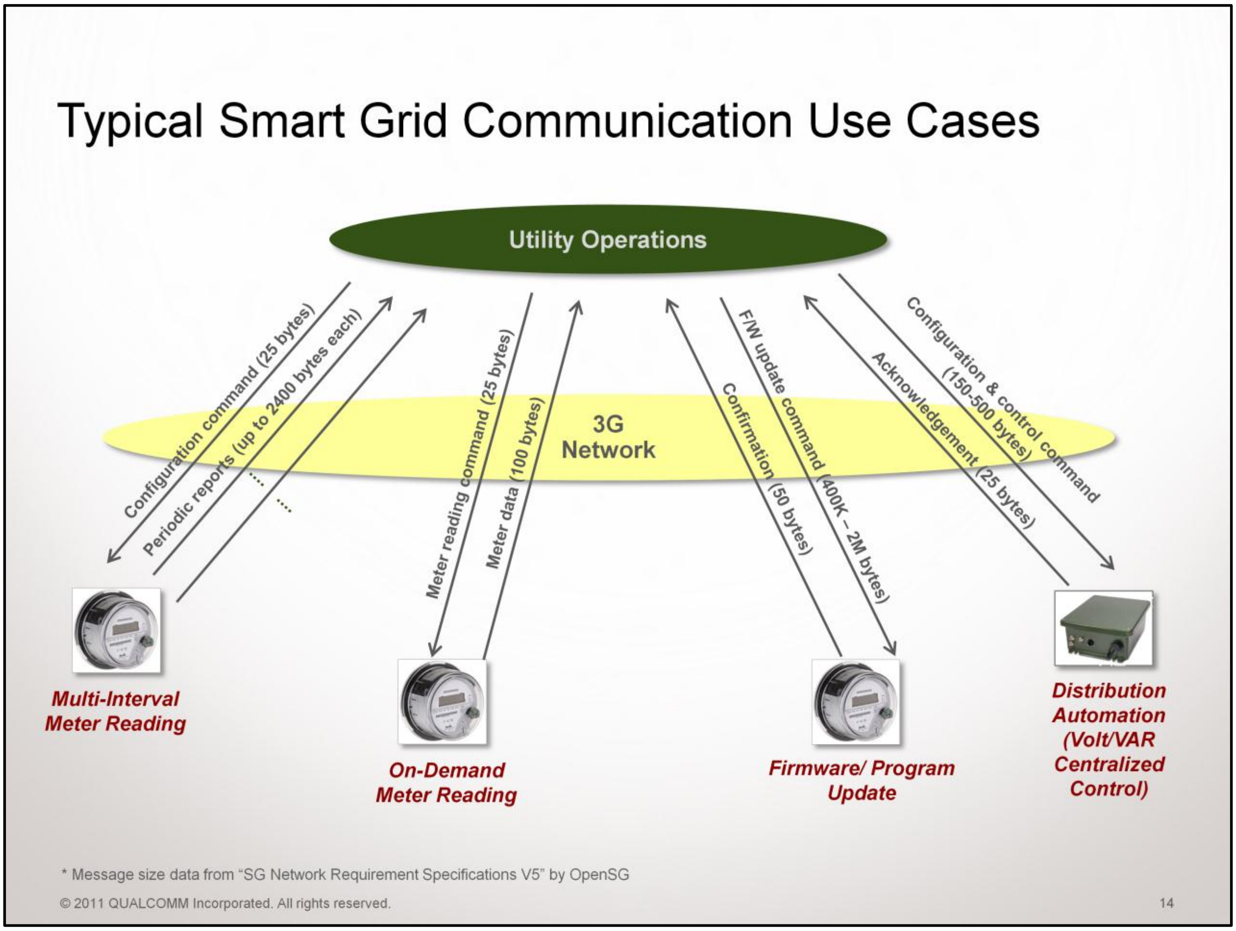

**Smart Grid Framework**

Smart Grid is the modernization of the traditional power grid to enable a number of utility and societal benefits including energy efficiency, improved system reliability, integration of distributed and renewable energy sources and cost savings.

Three key elements enable smart grid:

- **Power layer**: The traditional electric grid system, encompassing generation, transmission, distribution and the end loads.
- **Communications layer:** A collection of communication networks that enable flow of information across the grid system. No single technology will cover all aspects and needs of the 'smarter grid'. Network requirements will be largely driven by the applications and use cases.
- **Application layer / use cases**: This is the intelligence over the communications layer that enable all promised benefits of the Smart Grid.

While meter reading has been the predominant topic of initial Smart Grid rollout, is expected that many other new applications will be added to the Smart Grid, unleashing new benefits – but also stressing the capabilities of the communications layer.




**Typical Smart Grid Communication Use Cases**

This diagram illustrates four typical smart grid communication use cases:

- **Multi-interval meter reading**: The meter is configured by the utility to report meter data around 4-6 times a day. Each report consists of multiple interval (e.g. one report every 30 minutes) meter data.
- **On-demand meter reading**: the utility queries the smart meter for meter data, and the smart meter is expected to report meter reading data in real time (< 5 sec.)
- **Firmware / program update**: the utility pushes new firmware images to the smart meters occasionally as a results of bug fixes or feature enhancements. The firmware images can be as large as 2MB and there is on average 2 firmware updates per year.
- **Distribution automation (volt/VAR centralized control):** the utility remotely sends commands to the distribution devices to change their configurations or to control their operations in real-time. A message latency of smaller than 1 second is expected.

# Summary of Use Case Characteristics & Requirements

| Use Cases: | Distribution Automation – Volt/VAR Centralized Control | Multi-Interval Meter Reading | On-Demand Meter Reading | Firmware/ Program Updates | Outage Manage-ment | Service Switch[2] | DR–Direct Load Control | Real-Time Pricing |
|---|---|---|---|---|---|---|---|---|
| **Latency** | < 1 sec per message | < 4 hours | < 5 sec per message | P2P: < 4hrs per meter. Broadcast/ Multicast: <7 days per 100,000 meters | < 5 sec per message | < 30 sec per message | < 5 sec per message | < 5 sec per message |
| **Interval** | CBC op: 1 per 12hr<br>CBC config.: 1 per wk<br>Sensor config.: 1 per wk<br>Reclosure config.: 1 per wk<br>Switch op: 1 per wk<br>Switch config.: 1 per wk<br>VR op: 1 per 2 hr<br>VR config.: 1 per 12 hr | 4-6 per meter per day | 25 per 1000 meters per day | 2 per meter per year | 1 per meter per event | 1-50 per 1000 meters per day | 60 per 1000 meters per day | 60 per 1000 meters per day (for each of CPP, TOU, and RTP) |
| **Device Density** | 15 devices per 1000 meters (projected to increase by 20X in 10 yrs) | Urban: 2000 meters/km$^2$<br>Sub-urban: 800 meters/km$^2$<br>Rural: 10 meters/km$^2$ | | | | | | |
| **Reliability**[1] | > 99.5% | > 98% | | | | | | |

[1] Reliability refers to the rate of successful message delivery.
[2] Remotely connect/disconnect service.

Data source:
- "SG Network Requirement Specifications V5" by OpenSG
- "Wireless Field Area Network Spectrum Assessment" by EPRI.

**CBC:** Capacitor Band Controller
**CPP:** Critical Peak Pricing
**DR:** Demand Response
**RTP:** Real-Time Pricing
**TOU:** Time of Usage
**VR:** Voltage Regulator



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**Summary of Use Case Characteristics and Requirements**

This table shows the key characteristics of selected Smart Grid Communication use cases. They include distribution automation, meter reading, firmware update, outage management, service switch, direct load control, and real-time pricing. Here we are focusing on the latency, traffic pattern, device density and reliability aspects of these use cases.

- Most real-time use cases require message latencies between 1 to 30 seconds. Distribution automation has the most stringent latency requirement at < 1 sec per message. Non-real-time use cases such as multi-interval meter reading and firmware update can tolerate latency of 4 hours and 7 days, respectively.

- The arrival rate of events ranges from several events per day, to 2 per year in the case of firmware update.

- The density of smart meters ranges from 10 per square km in rural areas to 2000 per square km in urban areas. There are on the average 15 distribution network devices every 1000 smart meters.

- Reliability requirements, as measured by the rate of successful message delivery, for most use cases are 98%. It is higher for Distribution Automation at 99.5%.

# Smart Grid Communication Network Requirements

| | Requirements |
|---|---|
| **Capacity**[1] | • Normal condition:<br>– 0.21 MB/hr/1000 population for smart meters<br>– 0.82 MB/hr/1000 population for distribution automation<br>• Critical/disaster condition:<br>– 2.54 MB/hr/1000 population for smart meters & distribution automation |
| **Message Latency**[2] | • < 5 sec for real-time smart meter operations<br>• < 1 sec for distribution automation operations |
| **Coverage**[3] | • Ubiquitous coverage in urban & suburban areas, and non-mountainous rural areas with > 0.2 persons per sq. km<br>• Coverage within 5 km of major roadways in mountainous areas |
| **Reliability**[2] | • > 98% for Smart Meter operations<br>• > 99.5% for Distribution Automation operations |
| **Security** | • Comply with NIST IR 7628 security guidelines |

References:
- Open SG, "SG Network Requirement Specifications V5"
- NIST, "Guideline for Assess Wireless Requirements for Smart Grid"
- EPRI, "Wireless Field Area Network Spectrum Assessment"

1 Based on OpenSG use cases and EPRI analysis. Assume 1 meter for every 3 people.
2 Data from OpenSG. Reliability is defined as the rate of successful message delivery.
3 Data from EPRI.

 

**Smart Grid Communication Network Requirements**

This table summarizes the network requirements based on the use cases we discussed.

- Data capacity requirement is around 0.21 MB/hr per 1000 population for smart meters and 0.82 MB/hr per 1000 population for distribution automation. Here it is assumed that there is one smart meter every three people.
- The network should be able to support message latency of 1 second for distribution automation and as low as 3 seconds for smart meter operations.
- The network should be able to provide ubiquitous coverage to support the installed base of smart meters and distribution devices.
- Message delivery reliability as low as 99.5% should be supported.
- On top of these, the network should be able to support security mechanisms based on NIST guidelines.

# Technology Comparison

## Summary of Technologies and Capabilities

| | 3G | GPRS | RF Mesh | PLC[4] |
|---|---|---|---|---|
| **Network Type** | Operator managed WAN | Operator managed WAN | Utility deployed and operated | Utility deployed and operated |
| **Topology** | Cellular | Cellular | Star, tree, and mesh | Power line |
| **Spectrum Type** | Licensed | Licensed | Unlicensed | Power-line |
| **Typical Data Rate**[1] | 1 Mbps | 40Kbps | 9.6 - 100+ Kbps | Several to 100+ Kbps |
| **Message Delivery Latency**[2] | < 1 sec | 1 sec or above | 1 - 60 sec | < 1 sec |
| **Coverage**[3] | • 98%+ US population. • 10s of meters to10s of km's per cell site. | • 98%+ US population. • 10s of meters to10s of km's per cell site. | • Up to 50m. • Can enhance coverage using mesh topologies. | • Up to multiple km's. • Data rate decreases with distance. |
| **Reliability/Avaiability**[3] | Rate of successful link establishment: > 99%. | Rate of successful link establishment: > 99%. | Deployment and product specific. | Dependent on the underlying power line. |
| **Security** | Provide authentication and confidentiality for over the air link. Application layer security mechanism can be deployed to ensure end-to-end security. | | | |

1 GPRS data represent theoretical for EDGE with 8 time-slots. PLC data rate is dependent on the link distance.
2 Typical values. Latency depends on network load and the number of hops between source and destination. Latency for RF Mesh and PLC also depends on the backhaul network used.
3 Coverage and reliability depend on both the technology and the specific deployment. The cost (both CapEx and OpEx) for deploying and maintaining a green-field network to meet the use case requirements should be taken into account.
4 Characteristics of typical narrowband PLC technology, e.g. G3 and PRIME.


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**Summary of Technologies and Capabilities**

This table gives a high level summary of the capabilities of several smart Grid communication technologies.

- 3G is an operator managed wide area network based on licensed spectrum. It can typically provide data rate well above 1 Mbps and supports message latency of small than 1 second. Currently covering more than 98% of US population, each cell site can have a range of 10's of meters to 10's of km's. Reliability is at 99% or higher.

- RF Mesh is deployed and operated mostly by the utilities using unlicensed 900MHz spectrum. It supports data rate up to around 100kbps, and message latency between 1 to 60 seconds. Each node has a range of up to 50m, but it can provide wide area coverage using mesh network topology. Reliability, as well as latency, are dependent on the network topology and the specific deployment scenario.

- PLC is not a wireless technology. It uses the power line as a communication medium, and can generally support 100kbps data rate with < 1 sec latency. Depending on the specific technology, it can support long communication range, but data rate degrades as the distance increases.

- All three technologies have certain built-in security features, while application layer security can be added per smart grid use case requirements.

## Technology Selection Considerations

| | 3G | GPRS | RF Mesh | PLC |
|---|---|---|---|---|
| Ease of network deployment and operation | • Deployed and maintained by cellular operators.<br>• Strong ecosystem that drives cost lower. | • Same as 3G. | • Utilities responsible for network deployment and maintenance.<br>• Requires new network. | • Utilities responsible for network deployment and maintenance. |
| Lifetime | • Mature technology with >300 networks worldwide.<br>• Still in deployment in various regions. | • Cellular operators refarming 2G spectrum for higher speed 3G / 4G networks. | • Limited vendor support.<br>• Proprietary point solution with no other known scalable use-cases. | • Dependent on long-term technology traction. |
| High capacity and performance | • High capacity with 2+ Mbps data rate today.<br>• Superior latency performance for real-time applications. | • Low data rate.<br>• Capacity/performance depends on voice traffic sharing the same RF carrier. | • Low capacity/data rate.<br>• Performance highly dependent on network configurations. | • Low data rate that degrades as distance between end points increases. |
| Low interference with other networks | • Use licensed spectrum that is protected from interference. | • Same as 3G. | • Use unlicensed spectrum shared by cordless phones, baby monitors, walkie-talkies. | • Operates in unsealed power cables.<br>• Might interfere with wireless technologies. |
| Available voice and data services for field operations | • Can utilize existing network service agreement to obtain voice/data services. | • Same as 3G. | • Must obtain voice/data services from an alternate network. | • Must obtain voice/data services from an alternate network. |

Support the feature    Partially support the feature    Do not support the feature




**Technology Selection Considerations**

This table summarizes some of the technology selection considerations, including ease of network deployment and operation, technology lifetime, capacity and performance, interference, and available add-on services and capability.

- 3G networks are deployed and operated by service providers. The strong ecosystem ensures availability of low-cost services and devices. For both RF Mesh and PLC, utilities are responsible for network deployment, operation and maintenance.
- 3G is a mature technology with more than 300 networks worldwide. It is constantly evolving to support better features and performance, and it is still being deployed in various regions. RF Mesh is a new technology with limited vendor support. Today, it is mostly a point solution with limited scalable use cases. The outlook of PLC depends on the long-term technology traction that it can generate.
- 3G offers high-data rate and superior latency performance. It can support large volume data transfer and real-time applications. RF Mesh has low data rate and its latency performance is highly dependent on network configurations. PLC’s data rate degrades as the distance between end points increases.
- 3G uses licensed spectrum and is protected from interference from other wireless systems. RF Mesh uses unlicensed spectrum that is shared by other products, such as walkie-talkie and upcoming IEEE 802.11ah based products. PLC operates in unsealed power cables that might be susceptible to interference.
- An add-on feature of 3G is that it can support voice and broadband data. Utilities can utilize the same service agreement to obtain voice and data services for their field operations. These capabilities are not available for RF Mesh and PLC.

# Comparison of Communications Technologies

| Use Cases | 3G | GPRS[1] | RF Mesh[2] | PLC[2] |
|---|---|---|---|---|
| Distribution Automation | Yes | Does not meet latency requirement | Does not meet latency requirement | Yes |
| Multi-Interval Meter Reading | Yes | Yes | Yes | Yes |
| On-Demand Meter Reading | Yes | Yes | Depends on network configuration. | Yes |
| Firmware / Program Updates | Yes[3] | Limited capacity | Limited capacity | Limited capacity |
| Outage Management | Yes[4] | Depends on network configuration. | Depends on network configuration. | Does not support outage reporting in some scenarios |
| Service Switch | Yes | Yes | | Yes |
| Demand Response – Direct Load Control | Yes | Yes | | Yes |
| Real-Time Pricing | Yes | Yes | | Yes |

Meet use case requirements — Partially meet use case requirements — Do not meet use case requirements

[1] GPRS shares time-slot resource with voice channels. Voice traffic is generally given high priority per operator policy.
[2] Utilities must deploy these networks to ensure adequate coverage and performance to meet the particular use case requirements
[3] Excess capacity at off-peak and high available throughput enable 3G networks to deliver firmware to large number of meters.
[4] High throughput and prioritized access mechanism enable 3G to support large volume of uplink traffic.

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**Comparison of Communications Technologies**

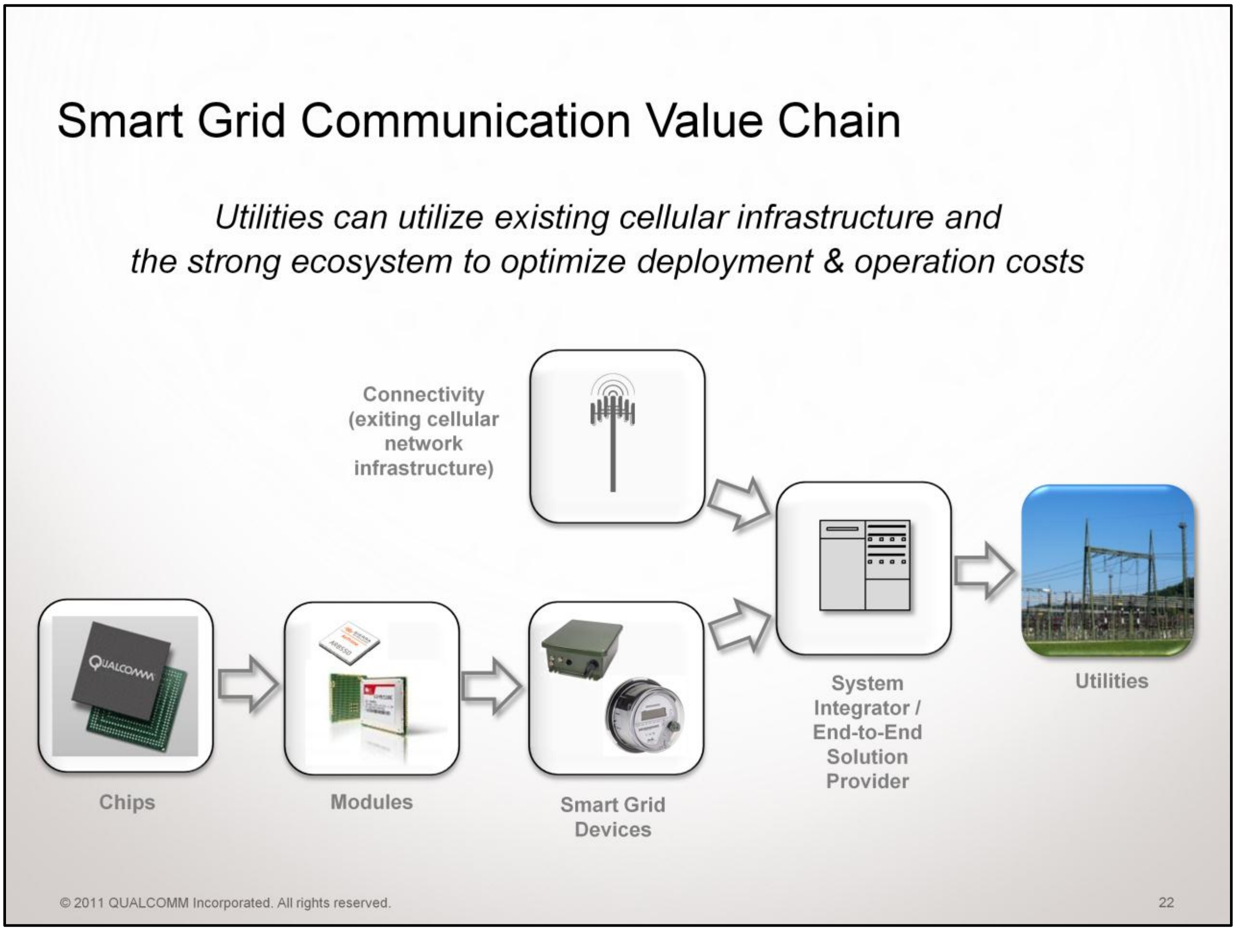
This table illustrates how well the three technologies support Smart Grid use cases:

- 3G supports high data rate and low latency. It also has a large network footprint with available coverage extension solutions. 3G networks are designed with reliability as a basic feature. It has high resilience and be able to recover from unexpected disruptions. 3G is able to meet the capacity, performance, coverage, and reliability requirements of the Smart Grid use cases.

- RF mesh has relatively high message delivery latency and is not a suitable solution for distribution automation. In general, the performance of RF Mesh is dependent on network configurations. Careful network design and engineering are needed to deliver the target performance and capacity.

- PLC is able to meet many of the use case requirements. However, firmware update will be challenging for PLC as high-data-rate is necessary to deliver large firmware images. PLC might also have problems detecting and reporting power line outages given that it relies on the power line itself to communicate.

# Implementing a 3G-enabled Smart Grid Communications System




**Smart Grid Communication Value Chain**

The machine-to-machine (M2M) communications value chain is usually very complex and fragmented, whether is for Smart Grid or any other vertical industry.

From a technical standpoint, these are the key entities in the M2M value chain when refers to utility implementations using cellular technology:

- **Chipset manufacturers:** Provide the fundamental technology building blocks, including cellular modem, application processors, memory, GPS, security engines, etc.
- **Cellular module OEMs:** Integrate chipsets into a cellular module (e.g. data card), provide software interfaces and certifications to operate with one or more cellular network operators.
- **Device OEMs:** Embed cellular module into utility devices, such as smart meters, communication nodes, distribution automation gateways, electric vehicle supply equipment and AMI concentrators.
- **Cellular network operator:** Provide connectivity for the utility devices enabled with cellular technology.
- **Utility:** Brings together the devices and connectivity to create a cellular-enabled smart grid system. System integrators and value-added resellers could also act on behalf of the utility in the development and operation of the solution.

## Strong Industry Support for Cellular Modules

- More than 100 cellular modules[1] from leading OEM manufacturers are available to suit a wide variety of requirements:
  - Cellular technology
  - Form factor
  - Environmental requirements
  - Valued-added features, e.g. GPS, processor.

[1] A partial list of cellular modules from various vendors is available at www.m2msearch.com



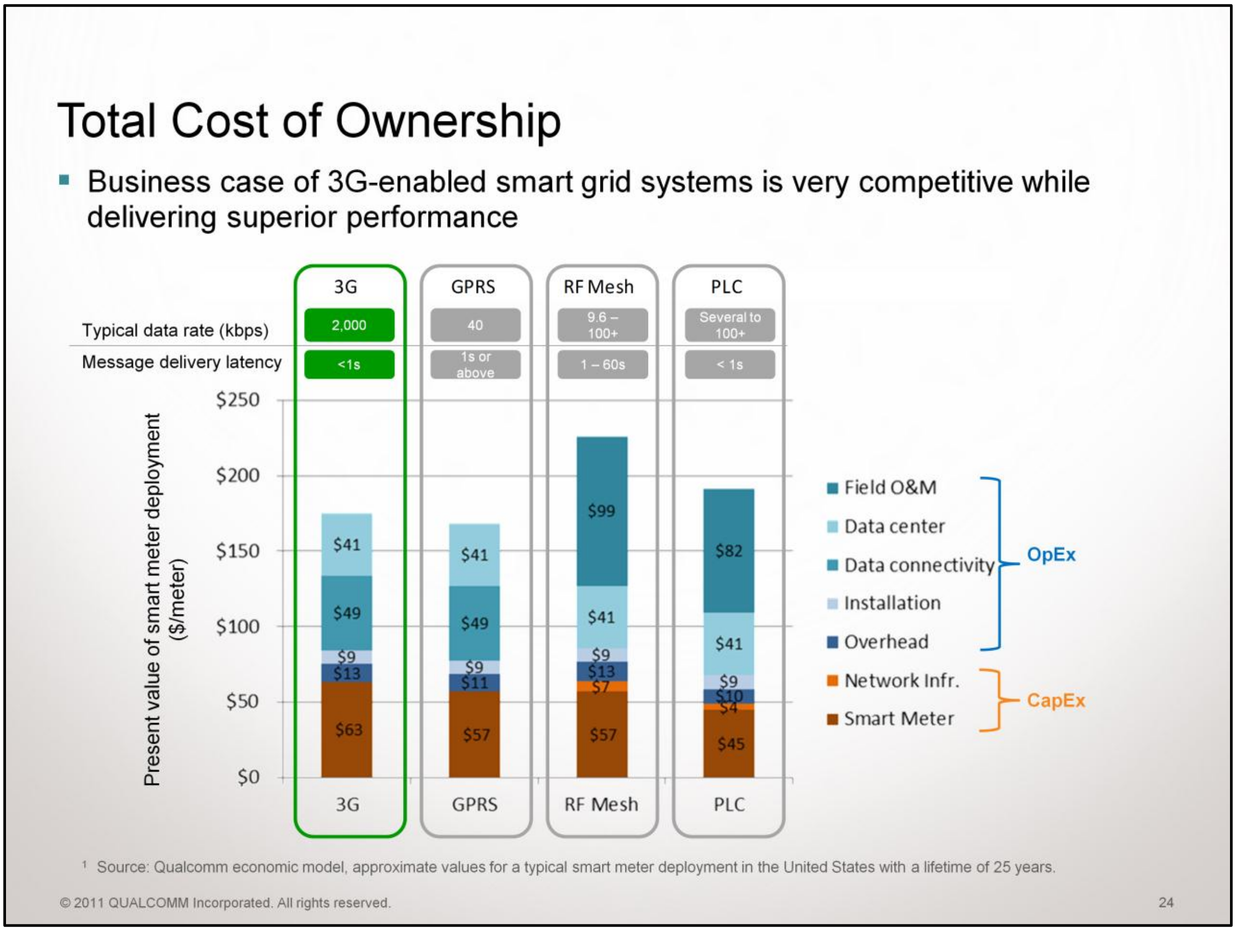


### Cellular Modules

Module manufacturers (also known as module OEMs) package cellular chipsets to produce cellular connectivity cards, or cellular modules. These module OEMs provide great value, as the use of cellular modules greatly simplifies the design process and reduces the cost of device certifications required by mobile network operators.

A well developed ecosystem of module OEMs provide cellular modules using a great variety of technologies, form factors, technical specifications (e.g. temperature range) and added functionality.

A database with cellular module specifications from various providers is publicly available at www.m2msearch.com.




**Total Cost of Ownership**

This chart shows the total cost of ownership (TCO) of the three technologies for a typical smart meter deployment. The model used for this chart calculates the present value of the TCO on a per-meter basis.

- The TCO consists of Capital Expenditures (CapEx) and Operating Expenditures (OpEx) components. CapEx includes communication modules, and devices costs, as well as network equipment and deployment costs. OpEx includes connectivity, operations and management, data center usage, and other overhead costs.

- 3G incurs data connectivity cost to the network operator that is not required by the other two technologies. However, this is offset by the Field Operations & Maintenance (O&M) cost that is a significant portion of the TCO for RF Mesh and PLC. Field O&M is not incurred by utilities in the 3G case, as this item is internalized by cellular network operators as part of their data services.

- Today, 3G can achieve the lowest TCO as shown in this model. This is the result of a dramatic decrease in the price of cellular connectivity in the last few years as cellular operators compete to win utility business. When taking performance into account, 3G delivers the highest performance and available data rate at the lowest cost.

- The business case of 3G-enabled smart grid system can match or be better than those of alternative technologies while delivering superior performance.

# Conclusion

## Key points from this presentation

***3G Networks provide an advanced and cost-effective solution for Smart Grid Communications***

- Strong ecosystem enables cost-effective deployment & operation.
- Mature technology supported by global standards.
- Highly reliable services with ubiquitous coverage.
- Strong commitments from operators and vendors on Smart Grid applications.

# Thank You



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