D2 Information Systems& Telecommunication

PS3 Increasing Operational Efficiency Using Packet Switched Communication Technologies

A Unified Communication Architecture for Smart Grid WAN/FAN/NAN Services

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The energy industry is facing unprecedented challenges and undergoing fundamental changes, impacting not only the network structure but also its operation. Clear trends indicate that utilities are looking for packet switched communication technologies with a higher data rate, lower latency, and connection capability supporting at least one order of magnitude higher online terminals/devices, so as to increase operational efficiency.

Currently, narrowband digital radio technologies (12.5 kHz or 25 kHz) are predominantly used by utilities for services requiring basic communication capabilities, such as utility supervisory control and data acquisition (SCADA) systems. Whilst certain minimum requirements will remain, smart grid networks are very likely to be enhanced with more intelligence and expanded for diverse applications, such as tele-protection, distribution automation, dynamic asset managements, which would require new radio technologies to support a higher data rate, lower latency and higher system capacity.

To meet these evolved requirements, a long-term solution is to refarm the existing narrowband spectrum allocation as continuous chucks of broadband spectrum, thereby permitting the use of mature broadband wireless technologies. While progress has been made in some countries, due to country-specific regulations and deployment conditions, many others still foresee difficulties in phasing out the existing narrowband system(s) under operation in a short term. For instance, China has allocated 223-235 MHz spectrum band with 25 kHz non-continuous narrowband carriers for utilities. Also, Ofcom (UK) recently announced that there will be no changes to the existing 12.5 kHz non-continuous narrowband spectrum allocations within the 450-470 MHz band for ten years, thereby ensuring continued access by the electricity, gas, and water users for smart grid solutions within the band. Thus, it is imperative for utilities to have a short-to-medium term solution to cope with the status quo, which can efficiently utilize the "fragmented and narrowband" spectrum to meet these evolved requirements.

From an architectural perspective, smart grid communications can be largely categorized as Wide Area Network (WAN) and Field/Neighborhood Area Network (FAN/NAN). In general, WAN is designed to backhaul data from FAN and Data Aggregation Point (DAP) into the network control center, and convey control commands from the network control to field devices. While FAN/NAN is intended to provide direct connectivity for smart grid end devices (e.g., Distributed Automation (DA) devices or Advanced Metering Infrastructure (AMI) devices) in a relatively small geographic area. The FAN gateway or DAP essentially acts as a bridge that collects, aggregates, and potentially locally processes data collected from the end devices, which then conveys the processed information to the network control center.

Based on real-world deployment experience, this paper introduces an innovative wireless communication technology, IoT-Grid (IoT-G), which is able to aggregate fragmented and narrowband utility spectrum to achieve broadband and low-latency transmission performance covering not only WAN-type but also FAN/NAN-type communications as outlined above. From a technical perspective, IoT-G inherits the successful air interface design elements of 3GPP Release 15 technologies for IoT services (such as NarrowBand-IoT (NB-IoT) and Long Term Evolution (LTE)), and supports smooth migration to the existing 5G communication technologies (features such as self-contained frame structure and grant-free transmission already supported). From a performance perspective, IoT-G achieves 50 ms air interface communication latency, 99.99% reliability and end-to-end full-service isolation and security, and multi-hop communication capabilities. Last but not least, IoT-G supports a number of technical features that facilitate harmony coexistence with the existing narrowband systems, such as interference-aware monitoring and frequency hopping.

IoT-G has passed multiple field tests in 2018 and is now under large-scale nationwide deployment in 7 provinces and 22 cities in China in 2019.

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