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Smart Gas Network (Smagan) based on IoT Ecosystem for Smart City

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ABSTRACT

Pressurized natural gas is the lifeline of each household in many of world's countries. But it requires a strong, viable, economical and technically efficient ecosystem to provide smart gas infrastructure. Use of PNG is advocated towards Swacch(Clean) India by eliminating use of conventional fuels like kerosene.

This paper intends to propose next generation smart gas network based on IOT sensors communicating over an efficient low power long range ecosystem using the machine learning based data analytics. This system connects the Government, Emergency and Vendor services to all the consumer in an integrated environment. The heart of this network is a secure, bi-directional communication based on established technologyand consumes ***low power and works over a long range*** *of area. The paper starts with explaining the need and requirement of the system. It further details down the basic components viz. sensor nodes, community gateways, vendor networks and the communication channel. The paper also details the overall power usage of this model and its efficiency during communication. Also, it discusses how data analytics done over cloud would help to predict the mass-emergencies, bulk-requests, etc. Lastly, it talks about possible future enhancements.*

KEYWORDS

Smart gas, low power, long range, machine learning, data analytics

INTRODUCTION

Today we are living in an energy efficient but much polluted world. Clean energy is the need of time and PNG fulfills that to large extent in major part of world. With the introduction of 'internet of things or 'Things'(IoT) [1] in our lives, the perspective of individual roles and responsibilities of the owner, vendor, authorities in the product maintenance, servicing, deployment have drastically changed. This paper intends to identify a **S**mart Gas Network (SmaGaN) on top of the IoT systems which consumes very low power and works over long distance. The requirement, benefits, issues of SmaGaN are discussed. Machine learning impact and importance of data analytics in predicting end-user needs and proposing marketing patterns are also discussed.

REQUIREMENTS OF THE SMAGAN

Every smart community is based on the realms of the advance needs ahead of the time. The main need is to have a gas network which is smart and based on low power, long range, reliable and scalable communication system. The gas network should serve the need like automated support, alert and notification. Further data generated from gas network should provide meaningful values to the administrative and vendor networks. Communication needs to be secure for all message flows from end-user to the vendor.

COMPONENTS OF SMAGAN

The main components comprising the SmaGaN ecosystem are:

- Smart Gas Meter End-nodes
- Gateways or Base Stations
- Network Server
- Gas data Analyzing BAckendSErvice Network (GABASEN)
- GOvernment, Vendor & Authority Network (GOVAN)

SMART GAS METER END-NODES

These smart gas end-nodes make the basic unit of the SmaGaN systems. These are low-power nodes viz. STM32Microcontroller [13] which receive data from Gas meter. End-node will reconcile the data in real-time and send the same to the gateway.

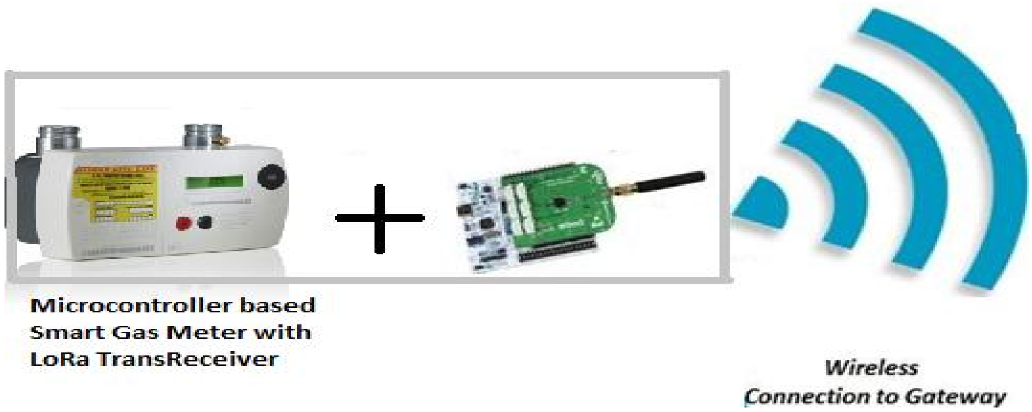

Figure 1: Smart gas meter with LoRa Trans receiver

SmaGaN has option of three different classes of end-nodes communication being based on LoRaWAN to address this need:

Class A, bi-directional: Class A end-nodes can schedule an uplink transmission based on their own needs. Each uplink transmission is followed by two short downlinks receive windows. It's important to note that downlink transmission to end-nodes at any other time has to wait until the next uplink transmission occurs. These have lowest power consumption.

Class B, bi-directional with scheduled receive slots: Class B end-nodes open extra receive windows at scheduled times. A synchronized beacon from the gateway is thus required, so that the network server is able to know when the end-device is listening.

Class C, bi-directional with maximal receive slots: Class C end-nodes have almost continuous receive windows. They thus have maximum power consumption. It should be noted that LoRaWAN does not enable

LoRaDevice-to-LoRaDevice communications i.e. packets can only be transmitted from an end-node to the network server, or vice-versa.

GATEWAY

Each Smart Gas end-node is connected to Gateway via a designated wireless channel. Gateways are located strategically based on no of smart meter in specific location and geolocation of Sensor nodes. The gateway forward packets coming from end-nodes to a network server over an IP backhaul interface for a bigger throughput.

Figure 2: Example of End-node LoRa transceiver [13] and Gateway [14]

NETWORK SERVER

The gateways serve as a link layer relay and forward the packet received from the smart gas end-nodes to the network server after adding information regarding the reception quality. Network server is responsible for detecting duplicate packets, choosing the appropriate gateway for sending a reply (if any), consequently for transmittingpackets to the end-nodes. Gateways will share the smart gas end-node data wirelessly to government, pre-contracted vendors or to authority in secure way. Correspondingly government agencies, vendors can further act or alert the responsible agencies or authorities to take immediate or long term actions. For Data analytics, the data would be shared with the authorized GABASEN. GABASEN would then providepredictive analysis to GOVANs for further actions.

GABASEN

The Gas data Analyzing Backend Service Network acts as service request analytics server for service requests coming from all smart gas end-nodes. The real benefit of the machine learning could be exploit when more than one GABASENs collaborate and enrich themselves by sharing datasets and learnings. GABASEN are proposed to have dedicated servers with huge processing capacities. These servers have data and learning as inputs and provide different types of analytics based on vendor requirements for their goal such as targeted marketing runs. These analytics will also help to improve the service quality from vendors by letting them be ready with the probability of expected gas service requests in future.

GOVAN

It connects house-holds smart gas meter to government, vendor and administrative authority services providers in SmaGaN. GOVAN provides access to paid, free & complimentary services providers. GOVANs are proposed to be connected to the Gateways via the public networks through secure communication protocols.

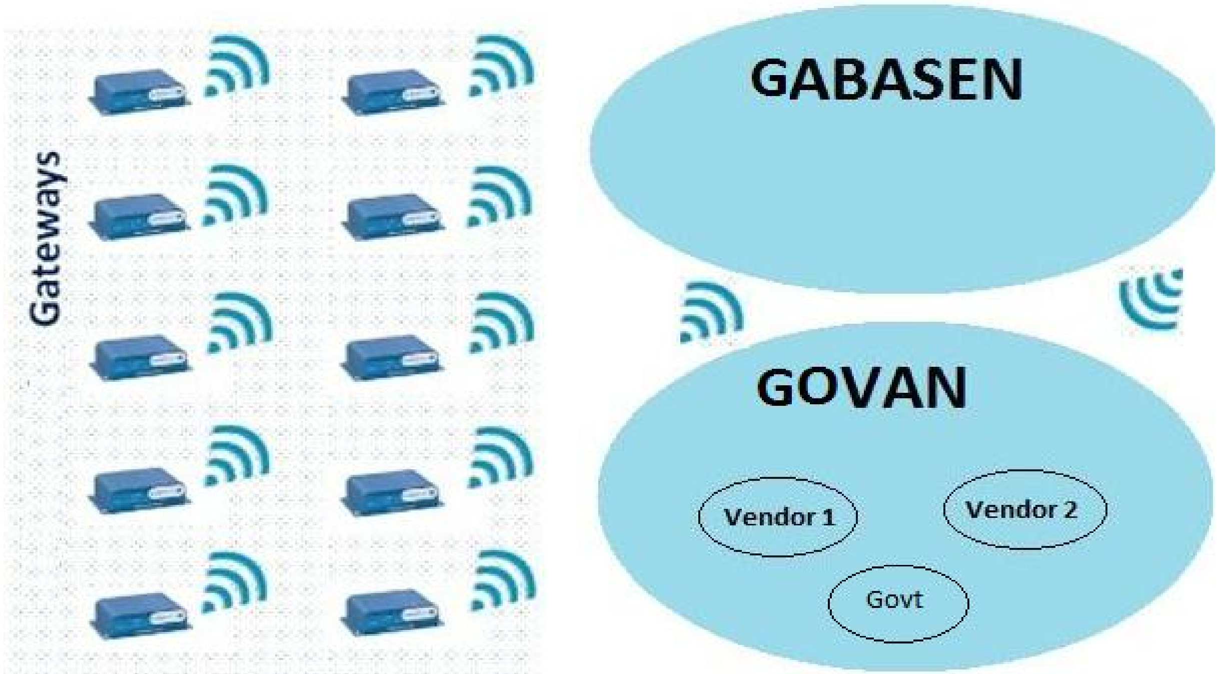

Figure 3: Gateway, network system, GABASEN & GOVAN

SMAGAN SECURITY

Security being a fundamental requirement, has been thought into the SmaGaN from the very beginning. The security is being handled by the core LoRaWAN. Main highlights are:

1) Mutual authentication is established between a LoRaWAN end-node and the LoRaWAN network as part of the network **join procedure.** This ensures that only genuine and authorized devices will be joined to genuine and authentic networks. LoRaWAN MAC and application messaging are origin-authenticated, integrity protected, replay protected, and encrypted. LoRaWAN security [12] uses the AES cryptography with CMAC2 for integrity protection and CTR3 for encryption as modes of operations. Each LoRaWAN device has a unique 128 bit AES key (called AppSKey) and a globally unique identifier (EUI-64-based DevEUI), both of which are used during the device authentication process. Application payloads are encrypted end-to-end between the end-device and the application server.

2) **Integrity protection**: The first step is hop through air provided by LoRaWAN protocol between end-nodes and network server. The next hop is between the network and application server by using secure transport solutions such as HTTPS and VPNs. The network server and GABASEN are also covered for integrity protection using similar secure transport solutions.

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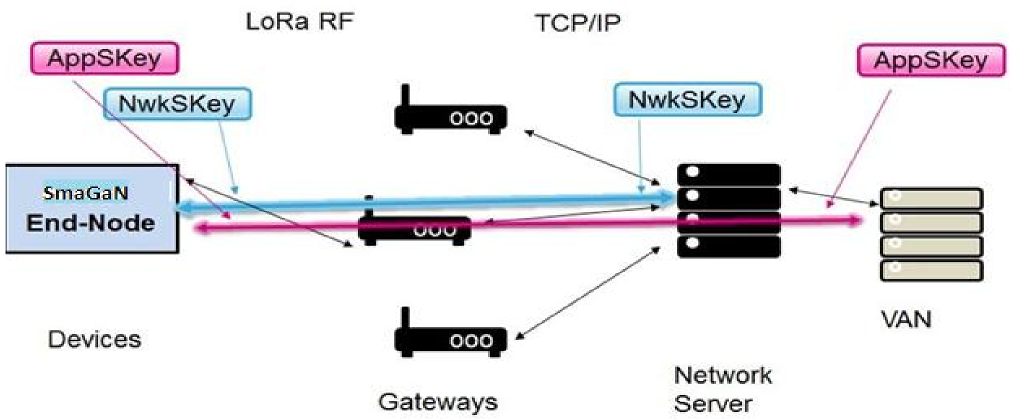

Figure 4: SmaGaN Security Design based on LoRaWAN

JOIN PROCEDURE

End device and network server have knowledge of AppSKey. The process starts by computing an AES-CMAC4 (using the AppSKey) on the device's join request and by the backend receiver. Two session keys are then derived. NwkSKey provide integrity protection and encryption of the LoRaWAN MAC commands and application payload. AppSKey provides end-to-end encryption of application payload. The NwkSKey verifies the authenticity and integrity of packets in LoRaWAN network. The AppSKey encrypts& decrypts the application payload in network-application server. There are two session keys to protect the traffic in LoRaWAN. First, to avoid packet replay, each payload is encrypted by AES-CTR and also carries a frame counter. Second, to avoid packet tampering, there is a Message Integrity Code (MIC) computed with AES-CMAC.

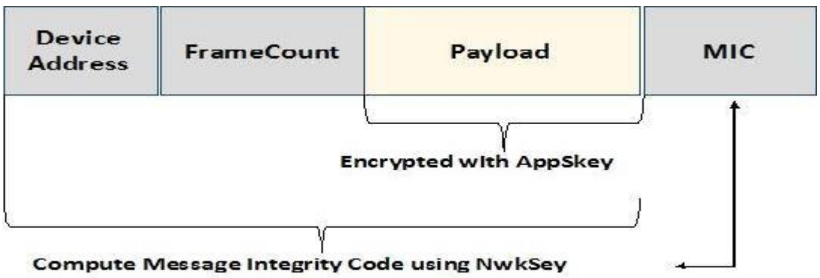

Figure 5: LoRaWAN Frame Format

LOW POWER LONG RANGE COMMUNICATION SYSTEM

One of the main requirements for SmaGaN is to have a widespread geographical coverage, so this rules out all LPLANs from consideration as they have a low range. The main highlight of LoRaWAN is its unlicensed spectrum. LoRa Technology will be best used for applications like smart buildings or campuses, where mobile network connectivity is not available or needed. LoRa also provides a steady RF coverage in rural, urban. LoRa and LoRaWAN have high link budget greater than any other standardized communication technology.

Based on the above study, LoRaWAN based on LoRa protocol seems best suited communication system for the SmaGaN.

FUTURE SCOPE

In future, integration of other sensors may be done in the smart gas meter. Since the LoRa communication module is proposed to be integrated in the smart meter, other IoT sensors like Gas leak sensor can be directly integrated in this ecosystem.
Further, Self-Debugging and self-healing IoT sensors can be integrated in the same gas meters. These further can interact with the meter utility company to notify detected faults or give an indication of improvement status.

CONCLUSION

SmaGaN is a smart gas ecosystem with long-range and low-power communication systems utilizing machine learned data analytics. It uses LoRa and LoRaWAN as underlying communication technology which is proprietary technology with a MAC protocol. LoRaWAN is an open standard with the specification available based on unlicensed ISM spectrum [2]. This paper gave a description of how smart meters will move to next generations with a built in communication trans-receiver like LoRa. This further mean that the smart meter industry is also benefitting from integration of IoT sensors relying on in-built communication module. SmaGaN is expected to offer network coverage of few km in a suburban area even with heavy residential coverage. SmaGaN is thus well suited to be implemented across all targeted smart cities nationally and worldwide.

REFERENCES

[1] Gubbi, J.; Buyya, R.; Marusic, S.; Palaniswamia, M. Internet of Things (IoT): A vision, architectural elements, and future directions. Future Gener. Comput. Syst. **2013**, 29, 1645–1660.
[2] LoRa Alliance. White Paper: A Technical Overview of Lora and Lorawan; The LoRa Alliance: San Ramon, CA, USA, 2015.
[3] IEEE 802 Working Group and Others. IEEE Standard for Local and Metropolitan Area Networks—Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs); IEEE Std 802.15.4-2011: New York, NY, USA, 2012.
[4] Baronti, P.; Pillai, P.; Chook, V.W.; Chessa, S.; Gotta, A.; Hu, Y.F.Wireless sensor networks: A survey on the state of the art and the 802.15. 4 and ZigBee standards. Comput. Commun. **2007**, 30, 1655–1695.
[5] Want, R.; Schilit, B.; Laskowski, D. Bluetooth le finds its niche. IEEE Pervasive Comput. **2013**, 12, 12–16.
[6] Khorov, E.; Lyakhov, A.; Krotov, A.; Guschin, A. A survey on ieee 802.11 ah: An enabling networking technology for smart cities. Comput. Commun. **2015**, 58, 53–69.
[7] Adame, T.; Bel, A.; Bellalta, B.; Barcelo, J.; Oliver, M. IEEE 802.11 ah: the wifi approach for M2M communications. IEEE Wirel. Commun. **2014**, 21, 144–152.
[8] Margelis, G.; Piechocki, R.; Kaleshi, D.; Thomas, P. Low throughput networks for the IoT: Lessons learned from industrial implementations. In Proceedings of the 2015 IEEE 2ndWorld Forum on Internet of Things (WF-IoT), Milan, Italy, 14–16 december 2015; pp. 181–186.
[9] Weyn, M.; Ergeerts, G.;Wante, L.; Vercauteren, C.; Hellinckx, P. Survey of the DASH7 alliance protocol for 433 MHz wireless sensor communication. Int. J. Distrib. Sens. Netw. **2013**, 9, 870430.
[10] ISO-IEC. ISO/IEC 18000-7:2014 Information Technology—Radio Frequency Identification for Item Management—Part 7: Parameters for Active Air Interface Communications at 433 MHz; ISO: Geneva, Switherland, 2014.
[11] Centenaro, M.; Vangelista, L.; Zanella, A.; Zorzi, M. Long-Range Communications in Unlicensed Bands: The Rising Stars in the IoT and Smart City Scenarios, 2015. Available online: http://arxiv.org/abs/1510.00620 (accessed on 2 August 2016).

[12] LoRa Alliance. White Paper: Lorawan security; The LoRa Alliance: Gemalto, Actility and Samtech USA, 2017.
[13] IoT connectivity made easier STM32 MCUs & LoRa: STMicroelectronics Pvt Ltd. http://www.st.com/content/ccc/resource/sales_and_marketing/presentation/product_presentation/group0/b5/72/c6/ec/c8/e3/4a/8c/IoTaugmented_stm32-lrwan/files/IoTaugmented_stm32-lrwan.pdf/jcr:content/translations/en.IoTaugmented_stm32-lrwan.pdf
[14] MultiConnect Conduit Programmable Gateway for the Internet of Things https://www.multitech.com/documents/publications/data-sheets/86002170.pdf