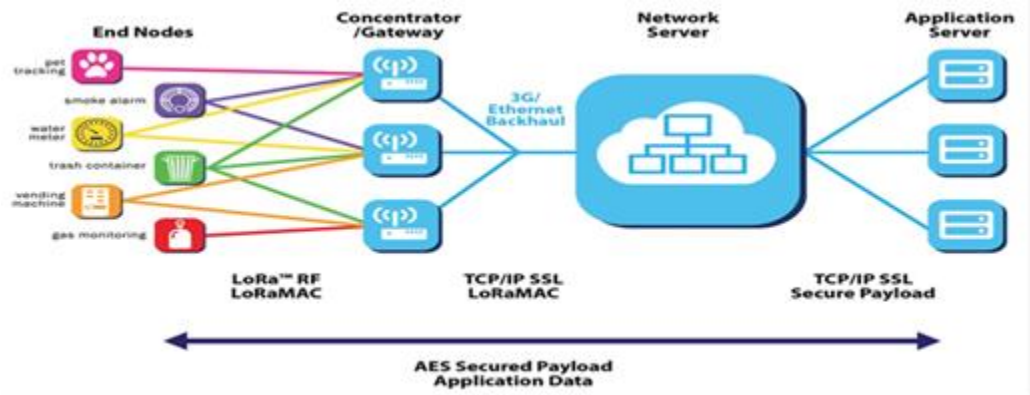
Bachelor Thesis 2020

Supervisor	**Tallal El-Shabrawy**
Institute/Department	**Information Engineering and Technology**
Mail address	Contact: Tallal.el-shabrawy&guc.edu.eg

Research field/project	Three Sixty Practical Capacity Analysis of LoRa Networks
Compulsory Qualification of students	Communication Networks/Internet Arduino/ESP Programming Cloud Knowledge is a Plus
Description	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries.  LoRa technology is pillared on a patented chirp spread spectrum (CSS) modulation scheme by Semtech. LoRa modulation is complemented with an open LoRaWAN (LoRa Wide Area Network) specification governed through the LoRa Alliance. The LoRaWAN network architecture is shown in the Figure. As shown in the figure, the patented LoRa modulation operates over the wireless link between end-devices (supporting diverse IoT use cases) and a LoRa gateway. The long-range of LoRa technology enables a single gateway to cover distances at the scale of up to 10 kilometers. The gateway then acts on behalf of the end-devices to forward their IoT messages/readings towards a network server (i.e. cloud). Application servers support different IoT applications by interacting with the data stored at the network server. Tha aim of this thesis is to evaluate the capacity of LoRa networks from end-to-end to assess where is the limiting factor for a LoRaWAN network. Within this context LoRa-based commerical IoT devices will communicate with a practical LoRa gateway. A network server will be configured over the Things Network open cloud infrastructure. Follwong that, probes on the traffic load at different links will be evaluated and used to analyze any capacity constraints of LoRa networks.

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Research field/project	**A LoRa Compliant SDR-Based Decoder**
Compulsory Qualification of students	Digital Communication Python Programming is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication In this thesis the student will implement a full LoRa compliant decoder that can communicate (transmit/receive) with a commercial LoRa device. The decoding and encoding will be implemented in software using python and the front end will rely on software defined radio. The ability of building a software-based LoRa compliant decoder opens the opportunity for investigating new physical layer techniques to enhance LoRa reception that is not possible within commercial LoRa receivers. The thesis is also part of a GUC smart city project where the developed decoder will be used as a gateway installed within the GUC to relay different sensor readings from across the full area of the GUC campus.

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Research field/project	**Analyzing and Mitigating Interference in LoRa Networks**
Compulsory Qualification of students	Mobile Communication Python Programming is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication LoRa relies on an ALOHA-based medium access control. In ultra-dense IoT networks collisions between concurrent transmissions of co-technology LoRa IoT devices is inevitable. Moreover, LoRa operates within the unlicensed Industrial, Scientific and Medical (ISM) band. Accordingly, interference from other uncoordinated LP-WAN technologies can also severely constraint the capacity that could be offered by LoRa. The main aim of the proposed research in this thesis is developing a practical LoRa receiver that could classify the type of interference affecting LoRa transmissions (possibly using machine learning) and accordingly deploy mechanisms to mitigate such interference. Commercial LoRa receivers are available and will be used to transmit known messages. A software-defined radio (SDR) based LoRa decoder will collect signals within the band of interest. The student will then use Python programming to analyse the received signal and apply interference mitigation techniques with emphasis on ISM interference.

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Research field/project	**LoRa-Based Localization using Machine Learning**
Compulsory Qualification of students	Wireless Communication/Mobile Communication Arduino/ESP Programming Python Programming is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication The emergence of LoRa opens the avenue for the localization of battery-powered devices at the scale of smart cities. This is attributed to the fact that LoRa communication could reach long-range distances at the scale of 10 Kms. Typically, the scale of city-wide localization has been achieved using GPS and cellular technologies. However, such techniques are quite power hungry and may be considered as impractical for battery-powered IoT devices. Accordingly, the emergence of LoRa-based localization sets the path for numerous new IoT application use cases that can enrich the contribution of IoT to the welfare of the human society as well as environment. One object of this project is to incorporate machine learning in the localization process to help minimize the distance error in the localization process.

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Research field/project	**GUC Smart City: A Web-Based LoRa Network Planning Software**
Compulsory Qualification of students	Communication Networks/Internet Mobile Communication HTML is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication In this thesis as part of the GUC smart city project, the student will implement and develop a web-based LoRa network planning tool. One of the most important aspects of any network design is a tool to assess the ideal location to place gateways and the coverage capability of the network gateway for both indoor and outdoor placed sensors. In that sense, the student will develop a web-based software that can specify the GUC environment. Following that and using well-known path-loss models, the tool can evaluate the LoRaWAN Network coverage at any location within the GUC campus. The results from the planning tool will also be compared against practical measurements.

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Research field/project	**GUC Smart City: A LoRaWAN Energy Monitoring System over The Things Network**
Compulsory Qualification of students	Communication Networks/Internet Arduino/ESP Programming Cloud Knowledge is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication In this thesis as part of the GUC smart city project, the student will implement an energy monitoring system. The energy monitoring system relies primarily on current/energy sensors that continuously report energy readings from different devices within the GUC. The backend of the monitoring system will be the open source Things Network. The student will then utilize machine learning techniques in the back end to assess the normal operation of sensed devices.

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Research field/project	**GUC Smart City: LoRa-Based Weather Station over Things Boards**
Compulsory Qualification of students	Communication Networks/Internet Arduino/ESP Programming Cloud Knowledge is a Plus
Description (URL for research information)	Recently, Low Power Wide Area Networks (LP-WAN) have emerged to become a key enabler for the realization of a multitude of IoT applications within smart cities, such as environmental monitoring, waste management, traffic control, and smart metering, just to name a few. LoRa has been exhibiting tremendous commercial growth to establish itself among the front runners of emerging LP-WAN, where the number of countries with LoRaWAN deployments has surpassed more than 140 countries. LoRa is pillared on its patented chirp spread spectrum modulation that supports energy-efficient/reliable long-range communication In this thesis as part of the GUC smart city project, the student will implement a weather station that measures temperature, humidity, wind, sun intensity among other sensors. The backend of the monitoring system will be the Things Board platform. The student will build a live dashboard for the weather readings from different locations within the GUC that could be seen accessed through the Internet. One of the direct applications for the weather station could be directed for the benefit of the GUC solar park.