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1. Introduction

During the previous semester I’ve been looking actively for an internship and finally I found a position in company “Orion System” which is located in Almaty, at Mametova and Seifullin streets. In headhunter there was a vacancy for python-developer and I sent my CV. Then I passed a job interview and the chief IT-manager asked me a lot of questions related to algorithms as well as some python-specific questions. For example, he asked me about Breadth First Search of graph: “how it works?”, “Where do we use it in real life?” and “What is the difference with Depth First Search?”. Next question was about sorting algorithms, especially about Insertion sort and its working algorithms. Then he asked questions about data types in Python. The last question was practical: it was a task about chess table and I had to write a pseudo-code on paper.

After all schedule and salary negotiations, I have been assigned to the position “Programmer of IT-department”.

2. About Company Orion System LLC

2.1 Orion System overview

### OrionM2M is a fully integrated developer and manufacturer of End2End Internet of Things solutions based on LoRaWAN technology.They design all their products in-house based on LoRa Alliance specifications.All software and hardware equipment is fully compliant with any LoRaWAN network. OrionM2M ™ is a member of the leading technology alliance in the field of wireless data transmission for the Internet of Things (IoT) LoRa ™ Alliance.

The company has been continuously promoting the adoption of LoRaWAN technology and solutions to enrich the lives of millions with digitally-native products that bring green energy, smart cities, and connected devices with an ultimate goal to build connected future.

In 2018 the natrionwide network LoRaWAN has become available in Kazakhstan. JSC Kazakhtelecom - the largest telecommunications company in Kazakhstan, which has the status of a national telecommunications operator, is in the process of building network based on this type of Internet of Things technologies - LoRaWan. All equipments as well as software were provided by company Orion System.

2.2 IoT(Internet of things)

2.2.1 *What is IoT?*

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

The Internet of Things refers to the ever-growing network of physical objects that feature an [IP address](https://www.webopedia.com/TERM/I/IP_address.html) for [internet](https://www.webopedia.com/TERM/I/Internet.html) connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. The Internet of Things extends internet connectivity beyond traditional devices like [desktop](https://www.webopedia.com/TERM/D/desktop.html) and [laptop computers](https://www.webopedia.com/TERM/L/laptop_computer.html), [smartphones](https://www.webopedia.com/TERM/S/smartphone.html) and [tablets](https://www.webopedia.com/TERM/T/tablet_PC.html) to a diverse range of devices and everyday things that utilize embedded technology to communicate and interact with the external environment, all via the Internet.

2.2.2.Brief history of IoT

The Internet of Things (IoT) has not been around for very long. However, there have been visions of machines communicating with one another since the early 1800s. Machines have been providing direct communications since the telegraph (the first landline) was developed in the 1830s and 1840s. Described as “wireless telegraphy,” the first radio voice transmission took place on June 3, 1900, providing another necessary component for developing the Internet of Things. The development of computers began in the 1950s.

Kevin Ashton, co-founder of the Auto-ID Center at MIT, first mentioned the internet of things in a presentation he made to Procter & Gamble (P&G) in 1999. Wanting to bring radio frequency ID (RFID) to the attention of P&G's senior management, Ashton called his presentation "Internet of Things" to incorporate the cool new trend of 1999: the internet. MIT professor Neil Gershenfeld's book, When Things Start to Think, also appearing in 1999, didn't use the exact term but provided a clear vision of where IoT was headed.IoT has evolved from the convergence of wireless technologies, microelectromechanical systems (MEMS), microservices and the internet. The convergence has helped tear down the silos between operational technology (OT) and information technology (IT), enabling unstructured machine-generated data to be analyzed for insights to drive improvements.

Although Ashton's was the first mention of the internet of things, the idea of connected devices has been around since the 1970s, under the monikers embedded internet and pervasive computing.

The first internet appliance, for example, was a Coke machine at Carnegie Mellon University in the early 1980s. Using the web, programmers could check the status of the machine and determine whether there would be a cold drink awaiting them, should they decide to make the trip to the machine.

IoT evolved from machine-to-machine (M2M) communication, i.e., machines connecting to each other via a network without human interaction. M2M refers to connecting a device to the cloud, managing it and collecting data.

Taking M2M to the next level, IoT is a sensor network of billions of smart devices that connect people, systems and other applications to collect and share data. As its foundation, M2M offers the connectivity that enables IoT.

The concept of the IoT ecosystem, however, didn't really come into its own until the middle of 2010 when, in part, the government of China said it would make IoT a strategic priority in its five-year plan.

2.2.3 How IoT works?

An IoT ecosystem consists of web-enabled smart devices that use embedded processors, sensors and communication hardware to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analyzed or analyzed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

The internet of things helps people live and work smarter as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their companies’ systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations.

IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods as well as offering transparency into customer transactions.

IoT touches every industry, including healthcare, finance, retail and manufacturing. Smart cities help citizens reduce waste and energy consumption and connected sensors are even used in farming to help monitor crop and cattle yields and predict growth patterns.

As such, IoT is one of the most important technologies of everyday life and it will continue to pick up steam as more businesses realize the potential of connected devices to keep them competitive.

2.3 M2M architecture

Machine to machine (M2M) is direct communication between devices using any communications channel, including [wired](https://en.wikipedia.org/wiki/Wired_communication) and [wireless](https://en.wikipedia.org/wiki/Wireless).Machine to machine communication can include industrial instrumentation, enabling a sensor or meter to communicate the information it records (such as temperature, inventory level, etc.) to application [software](https://en.wikipedia.org/wiki/Software) that can use it (for example, adjusting an industrial process based on temperature or placing orders to replenish inventory).Such communication was originally accomplished by having a remote network of machines relay information back to a central hub for analysis, which would then be rerouted into a system like a [personal computer](https://en.wikipedia.org/wiki/Personal_computer).

More recent machine to machine communication has changed into a system of networks that transmits data to personal appliances. The expansion of [IP](https://en.wikipedia.org/wiki/Internet_Protocol) networks around the world has made machine to machine communication quicker and easier while using less power.These networks also allow new business opportunities for consumers and suppliers.

So how does IoT differ from the more traditional Machine to Machine (M2M) term? The key is IP (Internet Protocol). M2M has mainly focused on direct point-to-point connectivity across mobile networks or fixed lines.

IoT communications involve IP networks and will usually employ cloud or middleware platforms. M2M is really about the communication only, not the broader processes and applications associated with IoT.

The main components of an M2M system include sensors a [Wi-Fi=](https://searchmobilecomputing.techtarget.com/definition/Wi-Fi), and [autonomic computing](https://whatis.techtarget.com/definition/autonomic-computing) software programmed to help a network device interpret data and make decisions. These M2M applications translate the data, which can trigger preprogrammed, automated actions.

Beyond being able to remotely monitor equipment and systems, the top benefits of M2M include:

* reduced costs by minimizing equipment maintenance and downtime;
* boosted revenue by revealing new business opportunities for servicing products in the field; and
* improved customer service by proactively monitoring and servicing equipment before it fails or only when it is needed.

While many use the terms interchangeably, M2M and IoT are not the same. IoT needs M2M, but M2M does not need IoT.

Both terms relate to the communication of connected devices, but M2M systems are often isolated, stand-alone networked equipment. IoT systems take M2M to the next level, bringing together disparate systems into one large, connected ecosystem.

M2M systems use point-to-point communications between machines, sensors and hardware over cellular or wired networks, while IoT systems rely on IP-based networks to send data collected from IoT-connected devices to gateways, the cloud or middleware platforms.

2.4 LoRaWAN technology

2.4.1. LoRaWAN  specification

LoRaWAN is a media access control (MAC) protocol for wide area networks. It is designed to allow low-powered devices to communicate with Internet-connected applications over long range wireless connections. LoRaWAN can be mapped to the second and third layer of the OSI model. It is implemented on top of LoRa or FSK modulation in industrial, scientific and medical (ISM) radio bands. The LoRaWAN protocols are defined by the LoRa Alliance and formalized in the LoRaWAN Specification which can be [downloaded](https://www.lora-alliance.org/lorawan-for-developers) on the LoRa Alliance website.

The LoRaWAN® specification is a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated ‘things’ to the internet in regional, national or global networks, and targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services.

LoRaWAN® network architecture is deployed in a star-of-stars topology in which gateways relay messages between end-devices and a central network server. The gateways are connected to the network server via standard IP connections and act as a transparent bridge, simply converting RF packets to IP packets and vice versa. The wireless communication takes advantage of the Long Range characteristics of the LoRaÒ physical layer, allowing a single-hop link between the end-device and one or many gateways. All modes are capable of bi-directional communication, and there is support for multicast addressing groups to make efficient use of spectrum during tasks such as Firmware Over-The-Air (FOTA) upgrades or other mass distribution messages.

The specification defines the device-to-infrastructure (LoRa®) physical layer parameters & (LoRaWAN®) protocol and so provides seamless interoperability between manufacturers, as demonstrated via the device certification program.  
While the specification defines the technical implementation, it does not define any commercial model or type of deployment (public, shared, private, enterprise) and so offers the industry the freedom to innovate and differentiate how it is used.

The LoRaWAN® specification is developed and maintained by the LoRa Alliance®: an open association of collaborating members.

LoRaWAN operates in unlicensed radio spectrum. This means that anyone can use the radio frequencies without having to pay million dollar fees for transmission rights. It is similar to WiFi, which uses the 2.4GHz and 5GHz ISM bands worldwide. Anyone is allowed to set up WiFi routers and transmit WiFi signals without the need for a license or permit.

LoRaWAN uses lower radio frequencies with a longer range. The fact that frequencies have a longer range also comes with more restrictions that are often country-specific. This poses a challenge for LoRaWAN, that tries to be as uniform as possible in all different regions of the world. As a result, LoRaWAN is specified for a number of bands for these regions. These bands are similar enough to support a region-agnostic protocol, but have a number of consequences for the implementation of the backend systems.

2.4.2. LoRaWAN vs Wi-Fi

We all know that WiFi is limited in range (you need to be within less than 15 meters of your access point) and can consume a lot of battery. This might be ok for our day to day use, but it is a problem for many IoT use cases. For instance, if you scatter sensors across a field, 1. you will need long range communication, 2. each will have very little battery. Therefore WiFi is not adapted.

Why don’t we all use LoRa then? Couldn’t we improve WiFi’s range and lower its power consumption? No, because for any wireless communication, there is a trade of between long range, low power consumption, and bandwidth. You can have two of these things, but it is always at the expense of the third.

WiFi’s bandwidth is huge (enabling us to e.g., watch ultra HD videos), it NEEDS, by the laws of physics a lot of energy (and a low range). At the other extreme, LoRa’s bandwidth is so low we could not even send a text file over the network.

Conclusion: LoRa is not a substitute to WiFi. However, LoRa’s low power requirement and long range capability enable IoT applications that would not be possible with WiFi.

2.4.3 LoRaWAN in Kazakhtelecom JSC

Kazakhtelecom JSC completed the first stage of the project on building the largest M2M/Internet of Things network in CIS based on LORA, Zigbee and LTE technologies.

Network covers all market segments of «Internet of things»: apartments, houses and entries in B2C segment; streets, multi apartment houses, administrative buildings, industrial objects and auto roads in B2B/B2G segment.

Within first stage building of the most scaled energy effective LPWAN network based on LORA technology with coverage of all multi apartment houses, buildings and city territory in Astana, Almaty and Shymkent in CIS was completed.

Besides, first stage of the project directed to preparing infrastructure in 9 thousand entries of multi apartment houses and connection of 17 thousand video cams to cloud video control platform, which secures collection and storage of video data from cams, installed in entries of multi apartment houses in 18 cities of Kazakhstan. Advantages of cloud video control are: online access to video from smart phone and other devices by means of developed mobile apps and web-portal. Also revision of archive videos with duration to 7 days is envisaged, safety of video data in COD of Tier 3 category, and integration with COU MIA/DIA on republican, city and regional levels. Till the end of 2018 coverage up to 33 thousand video cams in 17,5 thousand entries is planned.

Also first stage includes diversion of SmartHome platform, which is realized as cloud solution with horizontal diversion and realization of various solutions of smart home based on Zigbee technology. This solution allows securing connection of IP-cams, movement sensors, opening windows and doors, smoke sensors, temperature and humidity. Platform is widened to 5 million devices and 1 million users, mobile apps is available for subscribers on base of iOS/Android for cam, sensors control.

It is expected that LORA networks will cover all oblast centers of Kazakhstan and Semei, Temirtau and Zhezkazgan cities within second stage of the project till the end of 2018. In aggregate within the project is planned to install over 400 LORA base stations in 19 cities covering more than 30 thousand multi apartment houses, about 1,5 million apartments and 6 926 square kilometers of city territory. New М2М networks will became a key infrastructure for realization of smart city solutions, in particular on automation of indices collection from resources metering devices (SmartMetering) and on smart lighting. Advantages of LORA network are high scalability at expense of large coverage radius (to 25km.), long term of end devices battery (to 10 years), and openness of its protocol for a wide devices spectrum.