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MODERN INTERNET OF THINGS FOR SMART CITIES

Abstract: The IoT concept combines a network of physical devices, transceivers and software which allows a user to manage these devices to perform various actions that will solve everyday problems of city residents. It allows exchanging data between devices, store and process data.

Creating common IoT architecture is a difficult task since there is a problem of connecting heterogeneous devices with heterogeneous data transfer protocols. The challenge will be to create the right architecture for urban IoT and methods that will solve the common problem with heterogeneous data.

This paper focuses on the practical use of IoT in an urban environment. Smart cities are based on the use of modern technologies for the implementation of certain administrative services. This practice allows creating unique services that allow city authorities to reduce costs, optimize and automate typical city processes. IoT allows municipalities to make citizens' life better. In addition, this paper addresses the example of the IoT technical implementation in Padova Smart City.

The urban IoT main goal is to make the Internet wider and more convenient for the life of people.

Keywords: Internet of Things (IoT), Smart City, heterogeneous data, heterogeneous devices, XML, EXI, web service, constrained protocol stack (HTML, TCP, IPv4, IPv6), unconstrained protocol stack (COaP, UDP, 6LoWPAN).

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СОВРЕМЕННЫЙ ИНТЕРНЕТ ВЕЩЕЙ ДЛЯ УМНЫХ ГОРОДОВ

Аннотация: Интернет Вещей (IoT) объединяет сеть физических устройств, транспортных узлов, программного обеспечения. Данная парадигма позволяет пользователю программировать устройства на выполнение определённых функций, которые позволят решить повседневные проблемы жителей города. Эта сеть позволяет обмениваться данными между устройствами, хранить и обрабатывать эти данные.

Создание общей архитектуры IoT является сложной задачей, так как существует проблема подключения разнородных устройств с разнородными протоколами передачи данных. Будет затронута проблема создания правильной архитектуры для городского IoT и методов, которые позволят решить распространенную проблему с разнородными данными.

Данная статья будет посвящена практическому использованию IoT в городской среде. Таким образом реализуется концепция Умных городов. Умные города основываются на использовании современных технологий для осуществления разнообразных административных услуг. Данная практика позволит создать уникальные сервисы, которые позволят городским органам снизить расходы, оптимизировать и автоматизировать типичные процессы города. IoT позволит муниципалитетам сделать жизнь граждан лучше. Кроме этого, данная статья затронет пример технической реализации IoT в городе Падуя.

Основная цель IoT - сделать Интернет более широким и удобным для жизни людей.

Ключевые слова: Интернет Вещей, Умный Город, разнородные данные, разнородные устройства, веб сервис, ограниченный стек

протоколов (HTML, TCP, IPv4, IPv6), неограниченный стек протоколов (COaP, UDP, 6LoWPAN).

The Internet of Things is the future of modern and smart cities. It is a new interaction paradigm. Its essence is that everyday objects come with microcontrollers and corresponding protocol stacks that allow devices to communicate with each other and with clients. In addition, IoT can interact with a wide range of devices, such as surveillance cameras, control sensors, household appliances and etc. It contributes to the development of applications that use a large heterogeneous data flow. The IoT paradigm finds application in many areas, such as industrial automation, assistance to the elderly, vehicles, intelligent energy management, road traffic management and others.

However, there is a problem in many areas of activity to which the concept of IoT can be applied. This difficulty led to the proliferation of incompatible technologies. Therefore, there is no clearly established strategy implementation of IoT because of the novelty paradigm. This makes it difficult to get investment for the implementation of these technologies.

The IoT paradigm has several advantages when used in an urban environment, as this strategy responds to a strong push in the management and automation of public affairs. Urban IoT has several advantages in managing and optimizing traditional public services. Examples of such services include transportation, lighting, video surveillance, garbage collection, air purification and others.

Currently, the most serious problem is the heterogeneous devices and technologies that are used. The situation is worsened by the economic component. In recent years investments into public services have been reduced. This situation prevents the IoT implementation from widespread use.

A possible way out of this situation is the development of services that combine social utility with an economic advantage for the city administration in terms of reducing operating expenses.

Examples of such services include the following services.

- Waste Management. Urban IoT can reduce the cost of waste collection, improve the quality of waste recycling, and optimize the tracking of garbage trucks.

- Air Quality. Urban IoT can provide air quality monitoring in areas, parks, highways, etc.
- Noise Monitoring. Urban IoT can collect noise statistics in the streets of the city. This approach allows building a noise map to affect citizens to be quieter.
- City Energy Consumption. Urban IoT can collect energy consumption statistics for the whole city. This approach allows building an energy map of the area to optimize energy consumption.
- Smart Lighting. Urban IoT can optimize the intensity of street lighting depending on the time of day, weather conditions, the presence of people and vehicles.

The IoT architecture

We conclude from the above examples that the Smart City services are based on the architecture with a control center consisting of heterogeneous devices located in whole city. These devices transmit data to the control center where data is processed, stored and managed. A key characteristic of urban IoT is the ability to work with various technologies, combining them into one extensive network.

Three main parts that make up the city IoT are a web-based approach, link layer technologies and devices (Fig. 1).

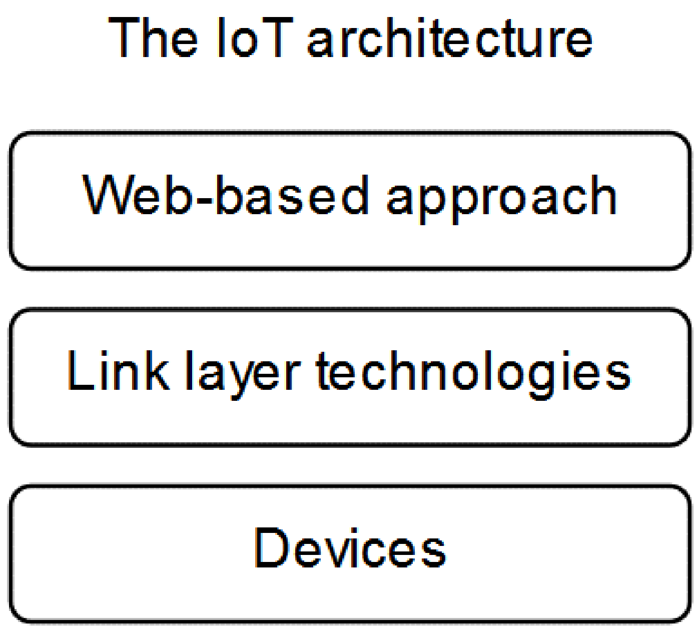

Fig. 1–The IoT architecture

IoT services, developed according to the REST web paradigm, are similar to web services. This approach makes it easier for users and developers to work with IoT, as it allows reusing most of the web knowledge. This paradigm is supported by international organizations, IETF, ETSI and W3C and research projects by SENSEI, IoT-A and Smart Santander.

The web-based approach supports both constrained and unconstrained protocol stacks. Their structure is standard and consists of data, application / transport layers and network.

Unconstrained stack consists of HTML / XML data, HTTP / TCP layers and IPv4 / IPv6 network protocols. This stack is the standard de facto on the traditional Internet. This stack has analogues in a constrained stack consisting of EXI data, CoAP / UDP layers and IPv6 / 6LoWPAN network protocols.

Data is exchanged with the description of transmitted content using specific languages, like XML. The disadvantages of the XML language include the large size of messages and the need to decrypt messages. Therefore, the W3C Consortium working group proposed the EXI format, which allows very limited devices to send and receive messages using an open XML-compatible data format.

Most of the global traffic uses the protocols HTTP, TCP. The complexity of the HTTP protocol and the weak scalability of the TCP protocol make them unsuitable for use in IoT. There is a CoAP protocol that is devoid of these shortcomings. This is a binary format transmitted via UDP.

It is possible to use HTTP and COaP devices on the network using a cross proxy that can directly translate requests and responses between the two protocols.

IPv4 and IPv6 protocols are widely used on the global Internet. The disadvantages of the IPv6 protocol include high resource consumption. This problem can be solved by the 6LoWPAN protocol, which is an IPv6 and UDP compression protocol in networks with limited capacity.

Urban IoT spans a wide area of a city and supports a large amount of data consisting of small data streams. Link layer technologies can be divided into unconstrained and constrained technologies. The first technology consists of LAN, MAN and WAN, LTE, Ethernet, WiFi, fiber optic network. Their features include high reliability, high data transfer rate and high energy consumption. Unconstrained technologies are characterized by low power consumption and low data transfer rates. Among the limited technologies are Bluetooth, NFC and RFID.

There are three types of devices. They are backend servers, gateways and IoT peripheral nodes. Backend servers collect, store and process data, ensuring the operation of the service. Gateways integrate end devices into a single infrastructure. IoT peripheral nodes are responsible for preparing the data sent to the control center.

Results

The architecture described earlier found its application with IoT implementation in Padova. This was made possible through the cooperation of municipalities and private companies. The main objective of this project is to facilitate the early implementation of IoT in the management of city life. The main services provided by Padova Smart City are the collection of data on the environmental situation and the management of street lighting.

These sensors collect environmental data such as carbon dioxide, noise, air humidity, vibrations, air temperature, and others.

The sensors are connected to the IoT node which provides power to the sensors and receives and sends data. The IoT node sends data to the control center. The control center processes this data and commands the sensors to perform certain functions. The control center can be connected to ordinary operators which are given the access to the sensor statistics and the ability to control certain functions (Fig. 2).

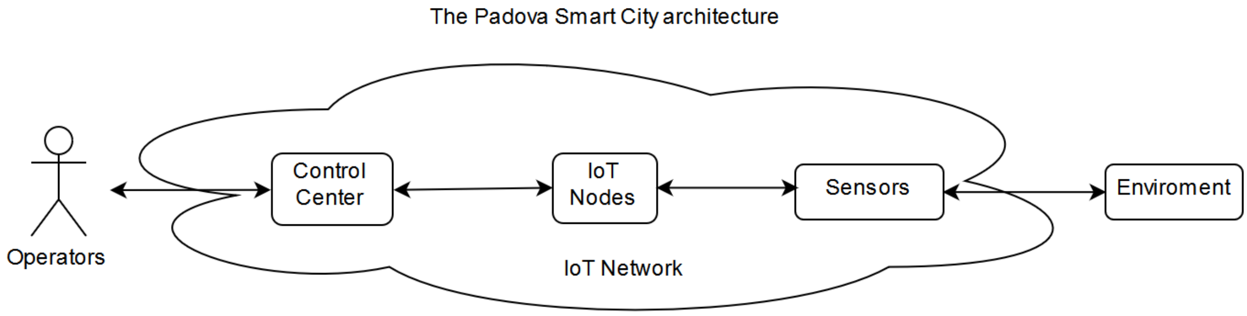

Fig. 2–The Padova Smart City architecture

Consider this architecture on the example of controlling the level of illumination in the city. The proper operation of the illumination in the city is provided with the help of sensors called photometers. Those sensors measure the intensity of light emitted by lamps at regular intervals or on request. IoT nodes are powered by small batteries and take up little space. Often, they are placed in a special casing that protects against atmospheric phenomena such as rain, wind and others.

The control center server collects data from the sensors. Information about this data can be presented in the form of a website or a mobile application.

For example, operators of municipal services using a mobile application quickly identify a faulty flashlight that requires an immediate call to a repair team. This system can be extended with additional IoT nodes that will be visualized in a mobile application. Such services include a sound map of a city, a map of energy consumption of a city, rate of temperature sensors in the whole city for the last seven days, etc. This allows citizens and municipality to see the whole situation, analyze certain changes in the city after rains, droughts, riots, catastrophes and etc.

In this paper were discussed in detail IoT, Smart Cities, the typical problems of interaction between heterogeneous devices in the IoT network, an example of the most profitable IoT architecture.

The tasks posed by this article are related to the urban IoT practical implementation. These tasks include choosing the right IoT architecture, testing this architecture using the example of Padova Smart City, summing up this experience and evaluating the application of this technology in the future.

The technologies that were discussed are currently close to standardization. The final problem is that industrial players become interested in the development of urban IoT to bring investment in these projects and make peoples' lives better.

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