Demonstration site for Smart Water Cities - Smart Campus Innsbruck

Pouvons-nous mesurer ce dont nous avons besoin pour des systèmes intelligents de getsion des eaux pluviales ?

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RÉSUMÉ

Les systèmes intelligents de gestion des eaux pluviales se caractérisent par l'utilisation de capteurs peu coûteux pour mesurer le comportement dynamique de l'ensemble du système, offrant ainsi de nouvelles possibilités d'exploitation. Les appareils de mesure installés dans les regards d'égouts, les égouts et les tranchées d'infiltration fonctionnent souvent avec des piles et des technologies de transfert de données sans fil pour transmettre les données. Pour donner une vue d'ensemble, une étude sur les technologies de transfert de données a été réalisée, y compris sur la portée et l'intervalle de transmission. Par la suite, ces informations ont été comparées avec les données nécessaires au contrôle en temps réel. Les intervalles de mesure et de transmission doivent être suffisamment fréquents, en particulier pour les stratégies de contrôle, qui impliquent de petits volumes de stockage. Grâce aux récents développements des Low Power Wide Area networks (réseaux longue distance à faible consommatoin énergétique), il est désormais possible de lire à distance les valeurs mesurées, ce qui permet de longues portées et de courts intervalles de transmission. Afin d'acquérir une expérience pratique dans le domaine des technologies de transfert de données sur le terrain, un campus universitaire d'Innsbruck (Autriche) est équipé d'appareils de mesure permettant de mesurer en quelques minutes les débits d'eau en provenance et à destination de cette zone. En complément, un Low Power Wide Area Network, abrégé LoRaWAN, a été mis en service en décembre 2018 et les emplacements intérieurs et extérieurs sur le terrain sont évalués.

ABSTRACT

Smart stormwater systems are characterised through the usage of low-cost sensors for measuring the dynamic behaviour of the entire system allowing new opportunities for operation. Measuring devices installed in manholes, sewers and infiltration trenches are often battery-powered using wireless data transfer technologies for data transmission. To provide an overview, a literature study on data transfer technologies was carried out including range and transmission interval. Afterwards, this information was compared with data requirements for real-time control. Especially for control strategies, which involve small storage volumes, the measuring and transmission interval should be sufficiently frequent. With the recent developments in Low Power Wide Area networks, a remote reading of measurement values is now possible allowing for long transmission ranges and short transmission intervals. In order to gather practical experiences within field data transfer technologies, the university campus of the faculty of engineering sciences in Innsbruck (Austria) is equipped with measurement devices to measure water flows to and from the area in the range of minutes. After several transmission tests, a Low Power Wide Area Network, namely LoRaWAN, is put in operation in December 2018 as an extension and both in field indoor and outdoor placements are evaluated.

KEYWORDS

data exchange, Low Power Wide Area Networks, real-time control, urban testbed, wireless

1 INTRODUCTION

In recent years, terms like ‘intelligent’, ‘real-time control’ and ‘smart stormwater systems’ have drawn significant research attraction. Although a range of centralized or decentralized applications with different control algorithms have been investigated, the basic principles of real-time controlled systems are the same: measuring, analysing and controlling (García, Barreiro-Gomez et al. 2015). Therefore, a functioning information and communication technology (ICT) is essential for the exchange of measurement values but also for control commands.

Nowadays, due to recent developments of smart stormwater systems, new opportunities for the development and implementation of real-time applications are emerging. Instead of one single measurement point, low-cost sensors can be easily integrated into existing systems monitoring the dynamic behaviour of the systems at a variety of manholes or decentralized low impact developments. With this information, water flows can be controlled all over the area (Kerkez 2018) allowing the real-time control of small storage volumes such as smart rain barrels (Oberascher, Zischg et al. 2019). Although there are already some experiences gained in the field of smart stormwater (Blumensaat, Ebi et al. 2017, Kerkez 2018), there is still a knowledge gap between what information can be gained and for what purpose it can be utilized

Applying measuring and control devices in the field of smart stormwater systems leads to the major problem how the data can be transmitted and handled efficiently. The various data transfer technologies differ whether wired or wireless, in range, field of operation, energy requirements but also in the maximal data throughput (Chen 2012, Li, Xu et al. 2014, Mahmoud and Mohamad 2016, Ray 2016). As the aim of real-time control is to improve efficiency, measuring devices are needed at underground structures and at remote locations. Thus, cabled technologies are not practicable solutions. Therefore, suitable measuring devices are mostly battery-powered using wireless technologies for data transmission. It is noteworthy that the power consumption is also increasing with increased data throughput, range or transmission.

The storage size of a single measurement point, consisting of timestamp, identification number and value(s) is in kilobyte. So comparing this size to up-to date data transfer technologies with data throughput in the order of Mbit/s or even Gbit/s, also low data throughput technologies (kbit/s) can be used. To increase battery lifetime, range and transmission interval need to be balanced for the required aim, strongly influencing the quality and efforts of online- monitoring and therefore subsequently also of real time control. But, the applicability of different data transfer technologies are in contrast to the requirements of a reliable real-time application. An example are the requirements for on-line monitoring of runoff in an existing sewer system. The peak-runoff rates in the sewer system are an important factor in the operation of real-time applications. The measurement devices are implemented into manholes requiring wireless data transfer technologies for the data transmission and batteries for power supply. For an efficient handling of the data remotely, the range of data transmission should be in balance with the number of required data concentrators and data loggers (i.e. how much measurement devices can be handled by a logger/concentrator). Besides the suitability of transmission technology, also a trade-off between investment and operational costs of the different devices has to be considered. For the outlined application, transmission ranges of at least some 100 m are needed. Finally, the measuring and transmission interval should be in minutes allowing the operation of real-time control with small storage volumes such as smart rain barrels (Oberascher, Zischg et al. 2019).

When combining the requirements of runoff measurements (1 min time step, range 100 m) with the conditions of the installation site (wireless, battery powered), the only applicable data transfer technologies remaining are part of the Low Power Wide Area Network (LPWAN) development. Examples are LoRaWAN and Sigfox, operating in unlicensed frequency bands, and NB-IoT and LTE-M supported by the mobile providers (Mekki, Bajic et al. 2018).

The objective of this paper is to present our experiences with smart water infrastructures gained from the Smart Campus, the university campus in Innsbruck and part of a pilot project for a Smart Water City. In contrast to other projects, stormwater and water supply system are combined in one project. This allows the utilization of synergies (hardware, data transfer, data management) and the assessment of the integrated impact of smart water systems in the context of smart cities.

Table 1: Comparison of different transfer technologies (adapted from Sinha, Wei et al. (2017), Mekki, Bajic et al. (2018))

Parameter\Technology	NB-IoT	LoRaWAN	Sigfox
Frequency	LTE (licensed)	868 MHz (unlicensed)	868 MHz (unlicensed)
Max. range	1 – 10 km	5 – 20 km	10 – 40 km
Data rate	200 kbit/s	50 kbit/s	0,1 kbit/s
Energy efficiency	> 10 years battery life	> 10 years battery life	> 10 years battery life
Bidirectional	Yes	Yes	Limited
Limitations	No	Duty Cycle	140 messages/day
Transmission interval	1 Minute*	1 Minute*	10 Minute
Latency	Low	High	High
Example Application	Real-Time Control	Peak-Flow detection	Storage tank level

2 METHOD

As these technologies are relatively new and still under development, little information is currently available on their applicability, especially in underground structures and at remote locations. To obtain real experiences with data transfer technologies, various measuring devices are implemented at the university campus in Innsbruck (Austria) testing different transfer technologies for data transmission (see Figure 1). This campus area, called “Smart Campus”, is part of a pilot project for Smart Water Cities integrating water supply and urban drainage into one overall controlled system.

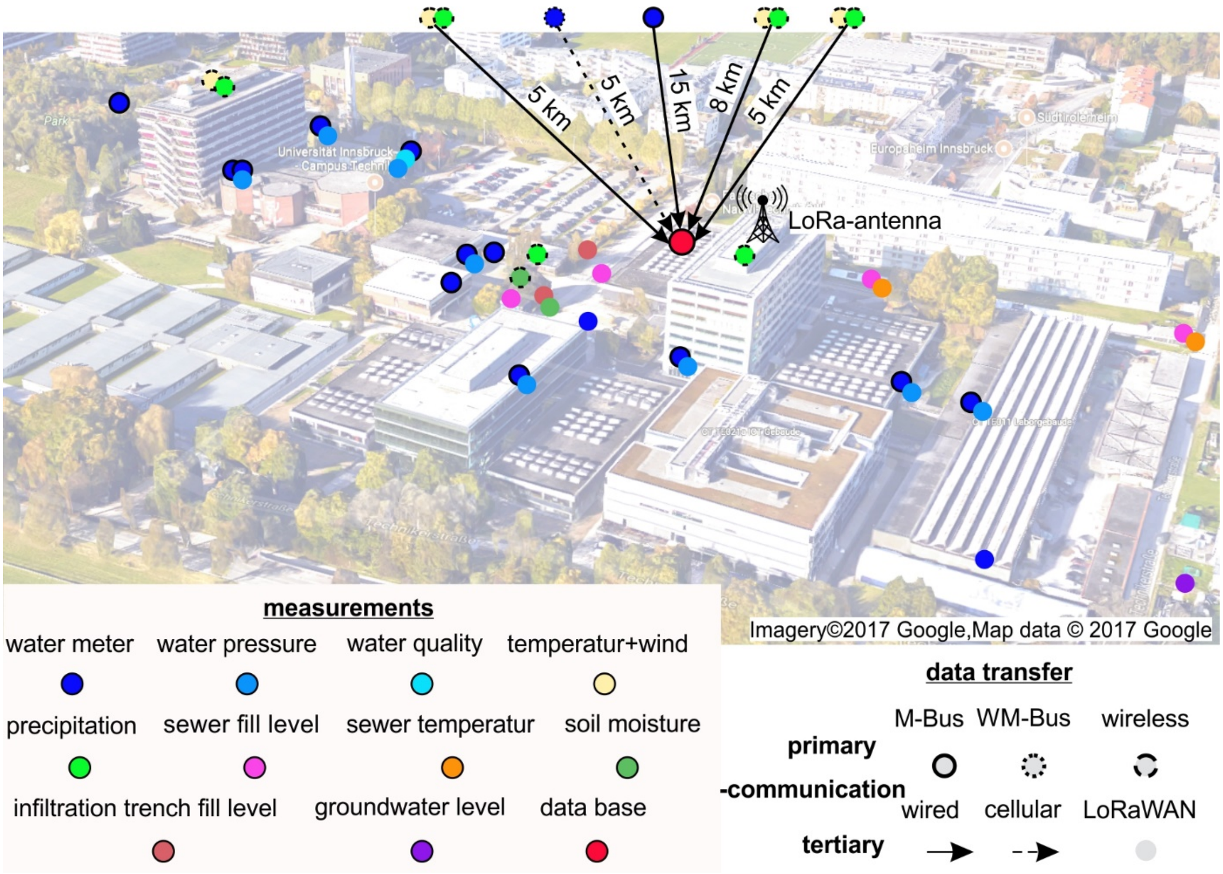

Figure 1: Smart Campus with measurement devices and data transfer technologies

3 RESULTS

At the campus area, water inflows and outflows from the campus area are measured in real-time, including filling levels of different LIDs and at controlling points in the central sewer system. The measuring devices and the chosen data transfer technologies can be seen in Figure 1. Overall, ten water meters, three tipping bucket rain gauges, one temperature/wind station and one soil moisture station were installed at the beginning of 2017 measuring weather conditions and water consumption in 1 to 15-minute steps. As an extension, a LPWAN, namely LoRaWAN, is put into operation in December 2018. To test the applicability of LoRaWAN, measurement devices are installed in different installation sites including outdoors, sewer and deep indoor placements. The LPWAN includes measurements of filling levels in sewers and infiltration trenches, temperature in wastewater, groundwater level, water consumption, water pressure and water quality.

The expansion by an LPWAN is expected to enable significant advances for real-time applications. The large variety of different installation sites (outdoor, sewer, cellars) will give a broad overview of the applicability of LPWAN and the results of the first few months will be presented.

4 CONCLUSIONS

Due to recent developments in information and technology communication, low-cost sensor powered by battery can be easily implemented in existing stormwater and water supply systems providing measurement data in high spatial and temporal resolution. To increase battery life of measurement devices and to reduce maintenance requirements, data throughput, range and transmission interval are limited. With the recent development in the field of Low Power Wide Area Networks, new data transfer technologies like LoRaWAN, Sigfox or NB-IoT are appearing, which are especially suitable for applications in urban water management. These technologies are providing great opportunities for remote reading of measurement devices due to their long transmission ranges and low energy consumption. However, the technologies are relatively new and still under development. As experiences show, there is a noticeable difference concerning range between manufacturers data and real application in sewer systems noticeable, which has to be investigated further in practice.

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