Paper reading 4

Thursday, May 7, 2020 11:10 PM

- What are the focuses of these papers?
- What problems do they want to solve?
- What strategies do they use?
- What are weakness, drawback or unsolved problems?
- What interests me, what I learned

Need data and graphs

4
Internet of Things for Smart Cities (link) *published as a journal paper at IEEE Internet of Things Journal.* This paper gives an example of large scale IoT system that can be deployed in real world. It especially focuses on the communication between edge IoT nodes and the server systems.

1. Focus of the paper
   An urban IoT system designed to support the Smart City vision.

2. Problems the paper wants to solve
   The objective is to discuss a general reference framework for the design of an urban IoT

   This paper offers a detailed survey on enabling technologies, protocols, and architecture for an urban IoT, before finally discussing the technical solutions and best-practice guidelines adopted in the Padova Smart City project.

   Section 2 of the paper: Smart city concept and services
   Concept:
   - Market
     Smart city has large estimated marketing size, but has not yet entered a rapid growth period. Multiple sectors of smart city are considered as the ranking criteria for evaluating "smartness" of European cities.
   - Obstacles in Political aspect
     Institutionalize the decision making process into one department to prevent the attribution of decision-making power to different stake-holders.
   - Technical issues
     noninteroperability of the existing heterogeneous technologies shall be solved by building a unified urban-scaled ICT platform based on IoT vision

- Financial aspect
  Still lacks a clear business model of a smart city. To account for this, the investors can first try smart city services that have clear and direct return on investment such as smart parking, and then aid the deployment of other added-value services.

  Services:
  These services are of particular interest because they improve the quality and the service for citizens while offering advantages to local government by reducing operational cost.
  The reason that those services are not widely used is because there are few accepted communication and architecture models to work in a harmonized way between different services.
- Structural Health of Buildings
  Urban IoT can collect building structural integrity measurements using sensors in or around the buildings, and store them in a public database. This saved the human work for structural checking. This approach may require an initial investment to install sensors and connect sensors to a control system.
- Waste Management
  An ICT solution that uses a control center to determine the best collector tracks route by accessing the smart waste containers load information would have economical and ecological advantages.
- Air Quality
  Air quality and pollution sensors can be deployed across the city to collect publicly displayed data to monitor the city air quality. By connecting the health applications on joggers' devices, people can know the healthiest way to jog.
- Noise Monitoring
  Noise sensors can be installed across the city to monitor the noise and build a space-time map of the noise as well as being used in safety alarming, but the installation of noise sensors are controversial because of the privacy concern.
- Traffic Congestion
  Using the sensors and GPS on modern vehicles and possibly noise and air quality sensors, a traffic congestion monitoring service can be implemented to aid the city authorities as well as citizens.
- City Energy Consumption
  By integrating the power draw monitors to the power grid, authorities and citizens can learn about the power consumption ranks and optimize the power consumption and generation scheme.
- Smart Parking
  Use road sensors to provide the best parking route would reduce CO emission,

traffic jam and increases citizen happiness. With the aid of near field sensing, parking lots can be reserved for residents and disabled to offer them better service.

- Smart Lighting
  By including street lights in the smart city plan, energy can be saved by adjusting city lighting according to the environment change. This has potentials for improve WiFi connection and fault detection.
- Automation and Salubrity of Public Buildings
  By monitoring and controlling the indoor environment and building energy consumption using proper sensors and actuators, comfort level of people can be improved, and thus probably increase the productivity of people.

Section 3 of the paper: URBAN IOT ARCHITECTURE

"The first characteristic of an urban IoT infrastructure, is its capability of integrating different technologies with the existing communication infrastructures.

The second characteristic is the necessity to make (part of) the data collected by the urban IoT easily accessible by authorities and citizens, "

1) Web Service Approach:
   "Focus on IETF standards because they are open and royalty-free, are based on Internet best practices, and can count on a wide community."
   Representational State Transfer (ReST) paradigm makes a flexible and interoperable web system available. Web system developed according the ReST is similar to traditional webs, therefore making it easier to adopt existing web technologies to IoT usage.
   A reference protocol architecture for the urban IoT system needed both the unconstrained and constrained protocol stack to gain easy access and interoperability for end devices with the Internet through transcoding operations.

- Data format
  It is preferred to use EXI format to describe the messages sent in an IoT system because it enables even constrained devices to "natively support and generate messages using an open data format compatible with XML"
  EXI has 2 types of encoding:
  Schema-less: encoded directly from XML(eXtensible Markup Language) and can be decoded by an EXI entity without first knowing anything about the data.
  Schema-informed: assumes two EXI entities share XML schema before encoding or decoding. This makes it possible to build multipurpose IoT nodes using

constrained devices, but developers have to design an XML schema for the data being transferred.
Integration of multiple XML/EXI data sources in an IoT system can be achieved by high-level databases that control nodes using data and the application.

- Application and Transport Layers
  HTTP is not suitable for IoT purpose because of its data redundancy and poor scalability for small data flows.
  CoAP can be used for IoT because it "proposed a binary format transported over UDP, handling only the retransmissions strictly required to provide a reliable service". It can also interoperate with HTTP well with a cross-proxy which "straightforwardly translates requests/responses between the two protocols" to enable transparent interoperation between native HTTP devices and the application.
- Network Layer
  IPv6 addresses are redundant for constrained nodes to process. The 6LoWPAN, an established compression format for IPv6 and UDP headers over low-power constrained networks, can ease the computation load for constrained nodes through the conversion between IPv6 and 6LoWPAN format using a border router.
  There are 3 ways to address an IPv6 host using an IPv4 address or other data in the packet:

a. v4/v6 Port Address Translation (v4/v6 PAT)
   "Maps arbitrary pairs of IPv4 addresses and TCP/UDP ports into IPv6 addresses and TCP/UDP ports". This has low complexity but has scalability problem to map multiple IPv6 ports to a single IPv4 nodes, caused by limited TCP/UDP nodes (65535). Connection is usually initiated by the IPv6 node.
b. v4/v6 Domain Name Conversion
   When requesting DNS for a domain name of an IoT web service "DNS returns the IPv4 address of an HTTP-CoAP cross proxy to be contacted to access the IoT node".
c. URI mapping
   Uses HTTP-CoAP reverse cross proxy to convert between IPv4/IPv6 by applied URI mapping function.

2) Link Layer Technologies
   An IoT system needs a link layer to cover a wide geographical area and to digest large amount of data flow.
   Unconstrained technologies are not suitable for IoT because of its high power consumption and complexity.
   Constrained technologies are used for IoT because of its lower power consumption, although having lower data transfer rate (usually <1Mbit/s).

3) Devices

- Backend services

  Locate in the "control center, where data are collected, stored, and processed to produce added-value services", interfacing with data feeders.

a. Database management systems

   Storing the information collected by IoT peripheral nodes.

b. Web sites

   Interfacing between data consumers and the IoT system.

c. Enterprise resource planning systems (ERP)

   Managing data flow across a complex organization for simpler data management.

- Gateways

To interconnect end devices to the main communication infrastructure.

This need to provide "protocol translation and functional mapping between the unconstrained protocols and their constrained counterparts", best if concentrating in a single gateway.

Also needs to provide interconnection between constrained nodes or between unconstrained nodes.

- IoT peripheral nodes

  Devices to produce data.

  RF tags, although most constrained, can be important because its low cost and no need for external power source.

  Mobile devices provide multiple ways to access IoT, and can probably make the interaction with IoT easier.

Section 4 of the paper: an experimental study: PADOVA SMART CITY

The Padova Smart City project was designed for "collecting environmental data and monitoring the public street lighting" by collecting "interesting environmental parameters, such as CO level, air temperature and humidity, vibrations, noise", while checking the operation of lighting system by monitoring light intensity at each post.

This example is representative for an urban IoT design because it involves various of devices and link layer technologies.

1) Components

- Street light

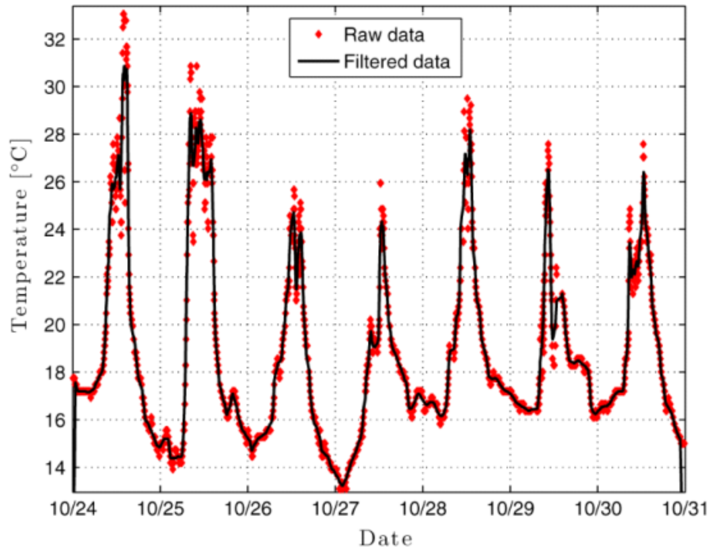
  Each streetlight is identified by an IoT node attached to it, which is equipped with photometer sensors, humidity and temperature sensors. There is also one benzene sensor. The IoT nodes are sealed inside transparent plastic shields to prevent environmental influence, and are powered by small batteries.

- Constrained link layer technologies

"Nodes form a 6LoWPAN multihop cloud using IEEE 802.15.4 constrained link layer technology. Routing functionalities are provided by the IPv6 Routing Protocol for Low power and Lossy Networks (RPL)". IPv6 addresses compressed through 6LoWPAN standard are assigned to each node. A sink node is used to gather all data and interface with the external nodes.

- WSN gateway
  Interfaces the constrained link layer technologies with the WAN technology for connecting to the backend. This also plays the part of a sink. Optical fibers are used for connecting to the backend.
- HTTP-CoAP proxy
  Enables transparent communication with CoAP devices. Can be designed to "support monitoring applications and limit the amount of traffic injected into the IoT peripheral network". e.g., can monitor resources by polling them or subscribing them, which locates on the switchboard gateway in the Padova Smart City system.
- Database server
  Collets data of resources for monitoring by communicating with the HTTP-CoAP proxy server. Data can be accessed from traditional web programming. In this example, it is realized in "the WSN Gateway, which hence represents a plug-and-play module that provides a transparent interface with the peripheral nodes".
- Operator mobile device
  The light operators will be equipped with mobile device to repair the IoT node onsite.

2) Example of data collected
   temperature, humidity, light, and benzene readings over a period of 7 days.
   "thick lines are obtained by applying a moving average filter over a time window of1h (approximately, 10 readings of temperature, humidity, and light, and 120 readings of the benzene sensor, whose sampling rate is larger since the node is powered by the grid)."
   Light peaks at daytime, reaches minimum at night, noisy at night because of car lights.
   Benzene lower at night because of lower traffic congestion.



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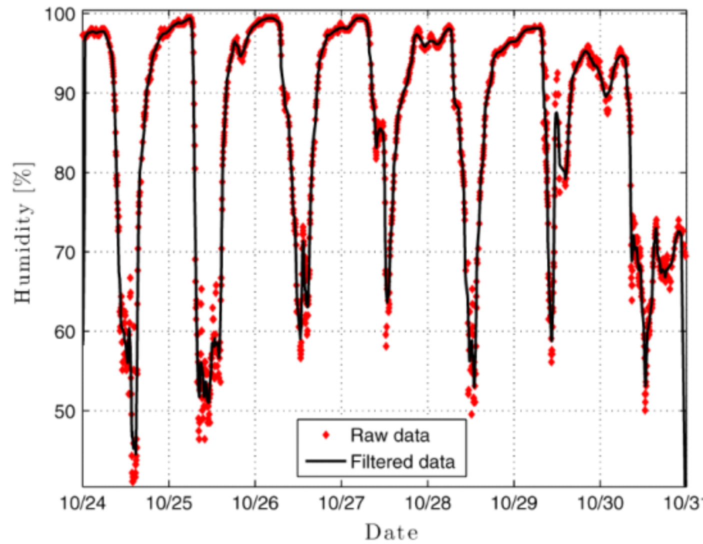

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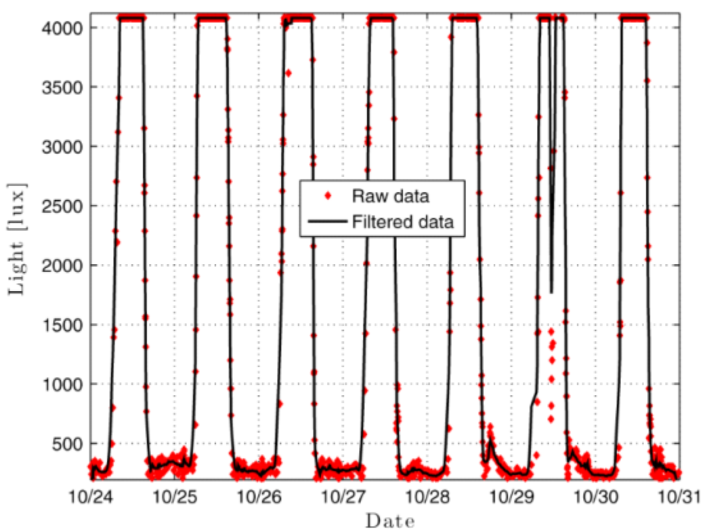

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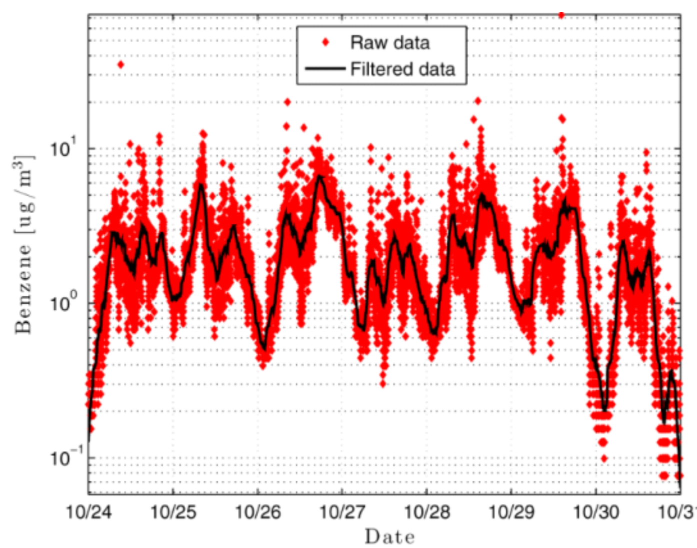

(b)

3. Strategies used

- Literature review
- Comparison between different methods
- Experiment in a city, deploying devices and collecting data

4. Unsolved problems, weakness, drawback

- This paper only introduces methods to use for deploying an IoT smart city system, but does not provide detailed steps for how to implement each component of the system.
- This paper mostly uses qualitative analysis to indicate the capability of some methods, but it needs more quantitative data to back up the claim that certain methods perform better.

- The Padova Smart City project example lacks a detailed analysis of the collected data. It is easy to collect data, but the most important issue is how the city administration interprets and uses the data to provide better service for the citizens as well as to reduce operational cost.

5. What interest me, what I learned
   The great potential of how a smart city model can aid the living standards of citizens and the operation of local governments interests me. The range of services is also very wide, including smart parking, building monitoring, environmental monitoring and traffic congestion management.