Ambient Air Alert Services based on Tailored Health Communication

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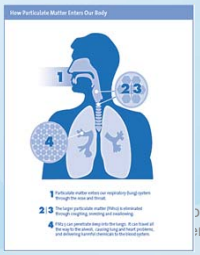
Abstract

The development of technologies and industries have lead us to an even more convenient life, but they might be also responsible to damage the environment. Air pollution is one of the effects. At certain time, most visible consequences of air pollution might be "smog". Therefore, many governments issue open data of Air Pollution Index(API) or Air Quality Index as outdoor reference. However, indoor air pollution or ambient environment might also be a worse toxic source. This research aims to provide a solution to alert ambient air pollution. The system, which is composed of hardware sensors and software agents, includes a set of web services to gather and compile data and a mobile application to communicate with users. The data source of the system are official open data as wide area data source and devices sensing data as local data source. All data is compiled and sent to the mobile application. The application not only uses data directly, but also adapts itself to fit users' personal health requirements. The research model of Tailored Health Communication is applied in the system to learn from users' feedbacks in order to provide more personal and accurate messages. Therefore, it is believed that with this service, the health impacts of air pollution can be reduced.

Introduction
Research Background

- In recent years, air quality has shown a significant influence in our daily life.
- Air Quality Index or Air Pollution Index is the number to show the public how the air quality is or will be.



World Health Organization(WHO) Outdoor air pollution[1]

- Air pollution is a major environmental risk to health.
- Ambient (outdoor air pollution) in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012.
- Some 88% of those premature deaths occurred in low- and middle-income countries, and the greatest number in the WHO Western Pacific and South-East Asia regions.

World Health Organization(WHO) Indoor air pollution[2]

- Over 4 million people die prematurely from illness attributable to the household air pollution from cooking with solid fuels.
- More than 50% of premature deaths due to pneumonia among children under 5 are caused by the particulate matter from household air pollution.
- 3.8 million premature deaths annually from noncommunicable diseases including stroke, ischaemic heart disease, chronic obstructive pulmonary disease (COPD) and lung cancer are attributed to exposure to household air pollution.

http://www.who.int/topics/air_pollution/en/

Introduction
Research Background

- In order to compute the AQI number, an air pollutant concentration over a period obtained from an air monitor is required.
- However, due to financial or other issues, installation of air monitor station is limited.

Introduction
Research Objectives

- Even if the station has increased, monitoring coverage is still inadequate.
  - We need more sensing devices and more coverage.
- Recent research suggests exposing in polluted air has bad influence to health, even just for a short-time.
  - To protect themselves, people need to know the air quality around them.

Introduction
Research Objectives

- Therefore, this research objectives are:
  - To design a light-weight personal air quality sensing device connected to user's smart phone
  - The device is able to sense and collect different types of air quality and then transmit the data to a cloud server via smartphone.
  - Cloud server not only collects and computes the data, but also notifies correspondent users if needed.

System Architecture
Devices

- Three kinds of air quality monitoring devices are designed.
  1. *InDoor* device has the most complete coverage of air pollution. It can be also used for home protection.
  2. *Personal* device is designed as a wearable decorate to monitor personal area.
  3. *Vehicle based* device is designed to be install on vehicles, so GPS is enabled.

System Architecture
Sensors

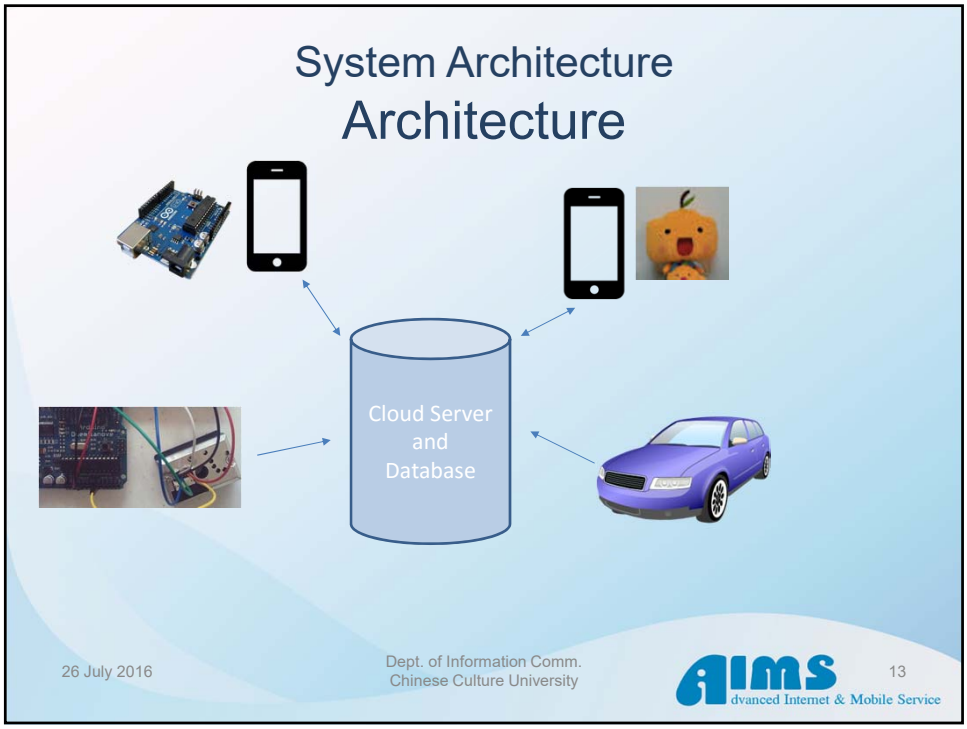
- MQ9, which senses Carbon monoxide and flammable gas, and MQ2, which can be used to detect Methane, Butane and liquefied flammable gas are used in *Indoor* devices.

System Architecture
Sensors

- MQ3 is a high sensitivity to alcohol, so it is very useful to prevent drunk driving.
- MP180 is a high precision , small volume pressure and temperature sensors.
- Sharp GP2Y1010AU0F uses LED to monitor dusts.
- Figaro2602 is used to monitor volatile organic compound (VOC).
- PM2.5 sensor SDS011

System Architecture
Connection Modules

- Since the monitor devices are designed for indoor, on the vehicle and personal wearable occasions, communication modules are different.
- Wifi connection is used for indoor devices, because no battery is needed and more sensors are installed.
- Bluetooth communication is used for personal and vehicle devices, because smartphones are responsible to transfer monitored data to servers.


System Architecture
Architecture
Cloud Server and Database
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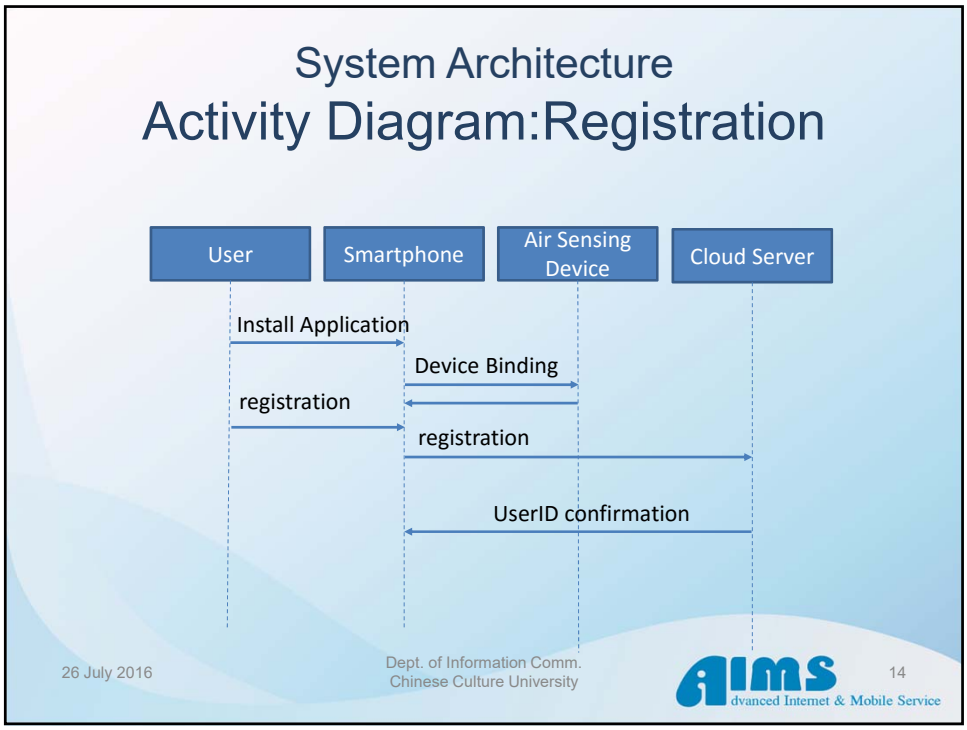
System Architecture
Activity Diagram:Registration
User
Smartphone
Air Sensing Device
Cloud Server
Install Application
Device Binding
registration
registration
UserID confirmation
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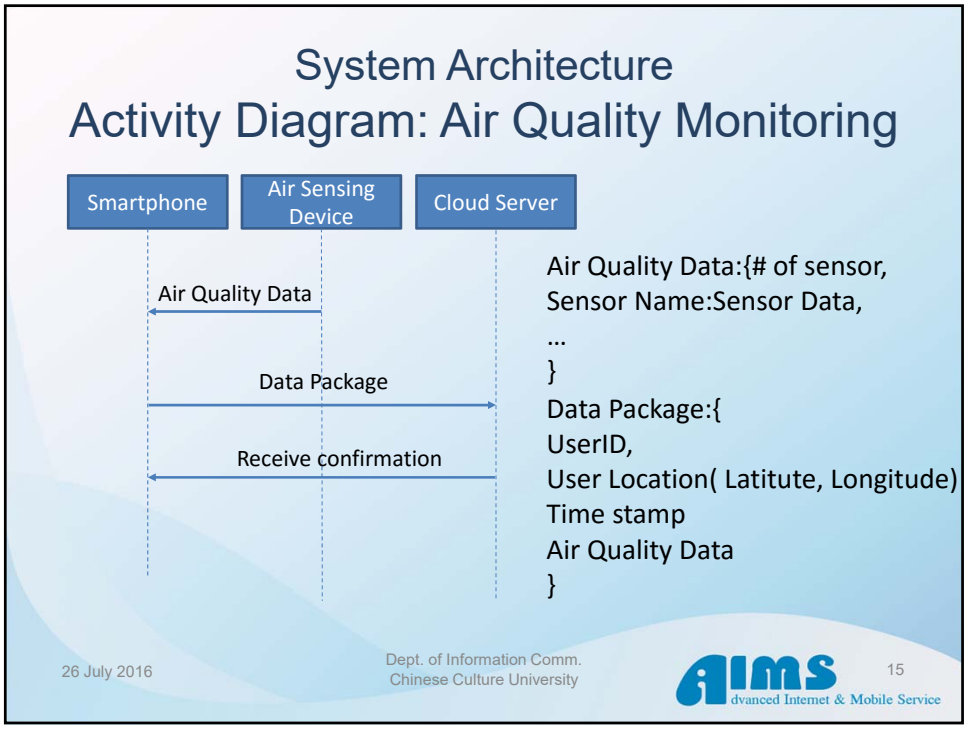
System Architecture
Activity Diagram: Air Quality Monitoring
Smartphone
Air Sensing Device
Cloud Server
Air Quality Data
Data Package
Receive confirmation
Air Quality Data:{# of sensor,
Sensor Name:Sensor Data,
…
}
Data Package:{
UserID,
User Location(Latitute, Longitude)
Time stamp
Air Quality Data
}
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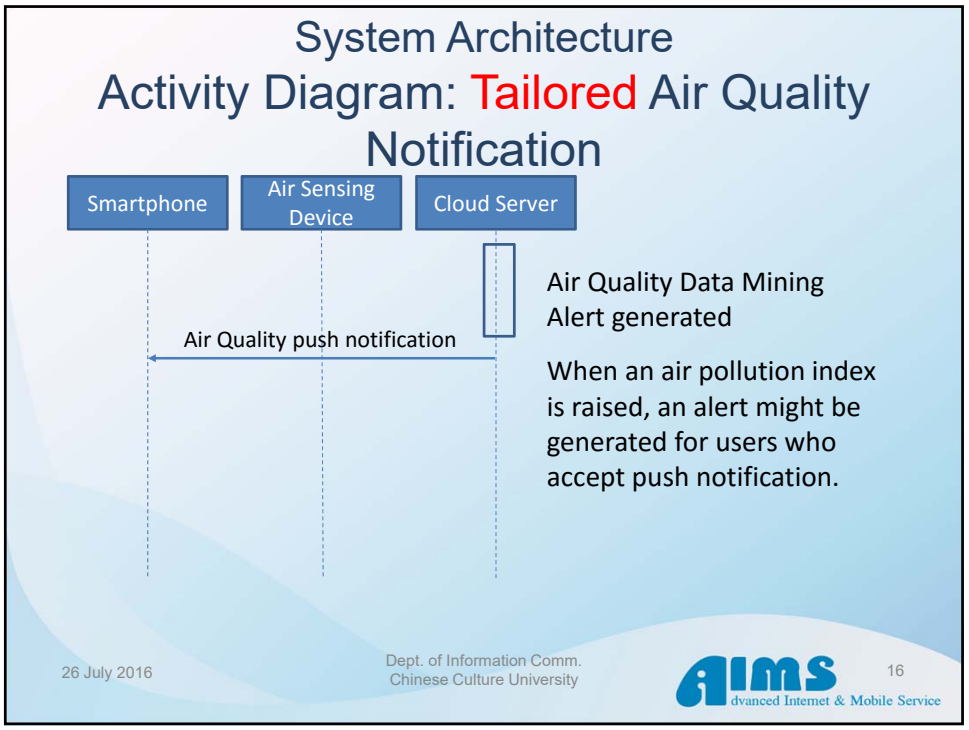
System Architecture
Activity Diagram: Tailored Air Quality Notification
Smartphone
Air Sensing Device
Cloud Server
Air Quality push notification
Air Quality Data Mining
Alert generated
When an air pollution index is raised, an alert might be generated for users who accept push notification.
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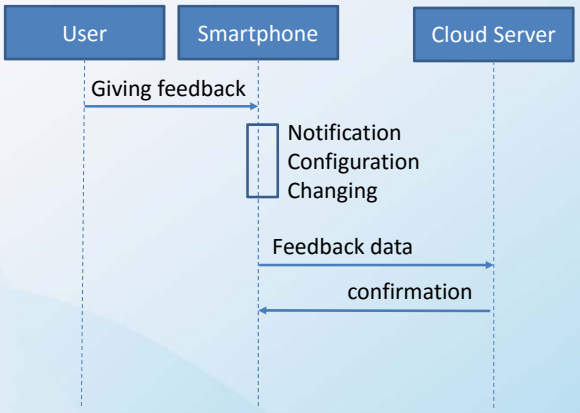
System Architecture
Activity Diagram:Feedback



- Every user has unique physical condition.
- They might react different symptom to different air pollution or air quality.
- Feedback service tries to personize push notification and learn from users' feedback.

Actions taken after Notification
Personal devices

- Once users receive air pollution alerts, the APPLICATION would suggest users to take actions.
  - Staying indoor.
  - Putting on a hygiene mask.
  - Moving to another location(if possible)
- Since everyone has unique health condition, personal feedback would be recorded and taken into consideration for future notifications.

Actions taken after Notification Indoor devices

- Since Indoor devices are designed for household, notification can be sent to pre-defined contacts.
- The Advanced IoT devices might be attached through SMART HOME services, if possible. Therefore, air cleaning devices might be activated.
- Once the situation goes south, the emergency respond service should be informed.

System Architecture
Tailored Health Communication

- 『'Tailoring' means creating communications in which information about a given individual is used to determine what specific content he or she will receive, the contexts or frames surrounding the content, by whom it will be presented and even through which channels it will be delivered.』
- It is believed that every user reacts differently to different air pollution. Someone might be more sensitive to dusts than others.

System Architecture

Tailored Health Communication

- When a user is giving his feeling as a feedback, air quality data, which contains data from different sensors, is retrieved and sent in the package to cloud server.
- A pre-defined machine learning method is processed when the package is received.

System Architecture

Tailored Health Communication

- The server then learn how to modify the weight of each factor (air pollution type).
- However, certain air conditions are known as contributing factors in many illnesses. Therefore, push notification is always activated when those factors reach alert level.

Air Pollution Value

$$PV = \sum_{i=1}^{n} (Wi * Fi)$$

PV**:** *Personal Notification Value*
F**:** *The data from a specific sensor*
W **:** *the weight for data "**F**"*

The air or air conditions are known as pathogenic or deadly factors are not included in the equation. They are always alerted.

Feedback changes Weight

$$W' = (1 - \alpha) * (W + adjustment) + \alpha * W$$

Once a new feedback is received, every weight of factor might be modified. The feedback is sent to the machine learning process to calculate "***adjustment***". The "***adjustment***" is used to compute the new weight "***W***".

Therefore, every user might receive their "tailored" notification according to their physical condition and preference.

Conclusion

- Air pollution is a major problem that badly influences human health condition.
- Although most governments have air monitor stations over the countries, the coverage of air monitors is still inadequate.

Conclusion

- With the idea of Crowdsourcing and personal air pollution monitoring devices, the monitored area can be extremely expanded.
- Therefore, we design three kinds of devices for indoor, mobile, and vehicle based environment.
  - Varied sensors are used in different occasions and locations. However, using indoor devices outside is possible, but not suggested, because the purposes of sensors are different.

Conclusion

- One of the usage of personal devices and mobile application is to send users the necessary air quality alert(s) by referring to their personal sensory.
- With long-term personalization, the air pollution notification be can “Tailored” (customized) according to user‘s preference.

Future Work and Conclusion

- The air pollution data is not only collected for personalization, but also prepared for further analysis.
- Once the server collects enough data, machine learning process can be activated.
- Once machine process is trained, personal movement, traffic condition, public transportation behaviours might be predictable. Air pollution ***forecast*** can be expected.

Research limitations

- Unfortunately, without adequate data, fault tolerance of the system is currently unsatisfied.
  - For instance, a user disembarking from a bus might cause the sensing result dramatically increase.
- Hopefully, it can be automatically identified when the sensing algorithm is trained and learned.

Reference

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