Smart Environment Protection in Wuxi

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Abstract—In this paper, we aim to propose a guidance and development of Environment protection and enhancement in Wuxi smart city. We start by presenting the importance of smart city and current state of the art of environmental protection technology in Wuxi and continue by proposing a line of smart government development for environmental enhancement that could positively impact the everyday life of its citizens. Moreover, we talk about the efficient solutions for environmental enhancement. These solutions however require integrated approaches, both at the level of research and development of advanced technological solutions, as well as at the level of deployment.

Keywords: Environmental protection, Smart city, Wuxi, Roadmap

1. INTRODUCTION

Smart cities appeared in late 80s as a means to visualize urban context and they evolve fast since then. Today, they enhance digital content and services in urban areas, they incorporate pervasive computing and they face environmental challenges. Various international cases present alternative approaches to the smart city, while they capitalize the Information and Communication Technologies (ICT) for multiple purposes, which vary from simple e-service delivery to sophisticated data collection for municipal decision making [1]. The fast growth of ICT technologies facilitates urban construction and development. Advanced wireless networks like 4G mobile broadband (MBB) make ubiquitous connectivity possible; cloud computing makes data sharing and integration, data mining and analysis possible; Unified Communications and Collaboration (UC&C) makes cross-sector collaboration possible and increases urban management and emergency response efficiency.

As discussed in [2], A Smart Sustainable City is a city that: (a) meets the needs of its present inhabitants (b) without compromising the ability for other people or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations. Smart City improves quality and intelligence of citizens' livelihood, and enhances environmental protection, public safety, urban services, and business activities. Thus, the concept of smart city is proposed to improve the quality of our lives. Meantime, we believe that the protection of key elements of our environment is important for human health. The ability to breathe clean air, to have a wholesome supply of drinking water and to be protected against harmful effects of things like waste and noise are fundamental to our well-being.

An important part of our work involves investigating, identifying and assessing environmental problems and then working out best approaches to tackle them. Meanwhile, environment protection has the meaning of general terms of all kinds of actions taken by human in order to solve practical or potential environmental issues, coordinate relationship between human and environment, and ensure a sustainable economic and social development. The methods and means are of engineering technology, administration as well as legal, economic, propaganda and education, etc. We believe there are a comprehensive set of solutions: Smart Government, Smart Monitoring especially including Air Quality Monitoring and Water Quality Monitoring.

2. SMART ENVIRONMENTAL MANAGEMENT

2.1 Smart government

We have observed two important trends with an impact in all these interactions. On one hand, governments around the world have engaged in a movement to open data with open licenses and in easier to re-use formats. On the other hand, technology ubiquity is contributing to the production of impressive amounts of data that have the potential to help us better understand complex social problems as well as to improve government relationships with citizens, private organizations, NGOs and other governments. Both trends together with a more extensive use of information technologies have been referred to as smart government or intelligent government. Smart government is considered as one of the key trends that governments have to follow for the next 10–15 years [3].

Hence, there are two main components for Wuxi government to be considered: the extensive use of technology by governments, and the extensive use of technology by citizens to interact with governments. In aspect of environment protection, we note that the functions of the government including the follows:

1) Environmental data ecosystem

Four key elements should be captured, namely, (1) releasing and publishing open environmental data on the Internet, Which promotes the influence and development of environmental protection, (2) searching, viewing, evaluating environmental data and their related licenses, (3) cleansing, analyzing, enriching, combining, linking and visualizing data, and (4) interpreting and discussing data and providing feedback to data providers and other stakeholders.

2) Sustainable Energy

The Wuxi government is responsible for ensuring the supply of energy, overseeing the effective planning of the energy sector, organizing the rights and duties of energy service providers in enhancing the cost-effectiveness and quality of the services provided to supply energy, rationalizing the use of energy and ensuring environmental sustainability. Thus, our goal is to support Wuxi's economic growth through secure energy supply and efficient energy use while meeting environmental and sustainability objectives and to diversify fuel mix by adding solar, clean coal, nuclear and other renewable sources of energy.

3) Building citizen awareness of environmental conservation

Building citizens' awareness for environmental conservation is very important nowadays. This is because current reality shows that public awareness of the various forms of behavior reflects a disregard for the environment. The low public awareness of the environment occurs in nearly all circles, both at the individual household, small community of forest squatters, as well as at the organizational level such as a company. Even at the level of intellectual concepts, the development ideas put forward by the scholars do not raise environmental problems in comparison to the ideas of political, economic, technological, and quality of human resources. The reality of such conditions, strengthen the idea that the attention to awareness of preserving and maintaining the environmental balance is very important and urgent [4].

Good governance is necessary, in addition to the enforcement of environmental laws. If the substance of the legislation does not guarantee the interests of the environment and is not pro-people, there will be a defiance of the people (Civil Disobedience) in complying with these laws and regulations. Therefore, there is a need to build environmental awareness through three approaches, namely a systematic approach to education, integrated and sustainable socio-cultural approach through the strengthening and development of local knowledge about environmental protection, and it takes the substance of law and consistent enforcement. Implementation of democratic culture must be offset by the strengthening and development of bio racy or bio democracy [4].

4) Environmental awards

The Wuxi government should create prizes for the Environment, which is aimed at supporting and encouraging environmental activities and the distinguished national individual and collective initiatives contributing to sustainable development.

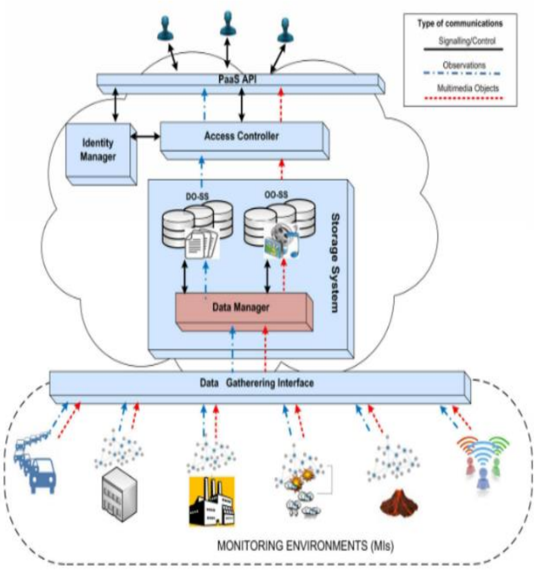

Fig.1 The Cloud storage service [9]

2.2 Smart monitoring and big data

Monitoring activities detect changes in the environment and can be used for several purpose. To develop new advanced services for smart environments, data gathered during the monitoring need to be stored, processed and correlated to different pieces of information that characterize or influence the environment itself. In the Internet of Things (IoT) perspective, billions of physical sensors and devices are interconnected through the Internet to provide many heterogeneous, complex and unstructured data. Many effort in the industry and in the research community have been focused on the storage of IoT data, in order to balance costs and performance for data maintenance and analysis [5].

Monitoring infrastructures in smart environments belong to different tenants spread on a worldwide area. There are several possible models that lead tenants to share their data over the Cloud. As shown in Fig. 1, a typical cloud storage system contains multi-media objects, observation technology and signal control system. For example, the tenants provides data as open sensing data through the web. In this case, the Cloud storage provider is interested in integrating such type of data in its system; or the tenant is at the same time both resource provider and consumer, and it exploits the Cloud to extend his physical infrastructure by means of the Cloud virtual infrastructure; otherwise, the Cloud storage provider and the tenant company make commercial agreements.

We can roughly classify such environmental data in two main types: (1) Observations: measurements of physical or composed phenomena performed by sensing devices. Observations can be expressed by tuples (key, value) and stored in text file forwarded across the network; (2) Objects: multimedia contents (e.g., audio, image, video and animation) recorded by information content processing devices [6]. Furthermore, after monitoring, large amount of data will be collected and then Based on the above discussion regarding the Big Data experience there are a number of suggested recommendations [7]:

(1) Review and recalibrate information and data policies as necessary.
(2) Robust data platform and architecture.
(3) Processing and computing power.
(4) Data standards
(5) Data sharing across sectors.
(6) Data curation, archiving, and preservation.
(7) Foster research and data communities.

However, providing open environmental data can be a costly process, both in terms of time and resources. Additionally, other issues such as apathy, confusion and untrusted quality-control cause databases owned and/or managed by many institutions to be not publicly accessible. As a consequence, the re-use and re-purpose of these data is often limited by intellectual property rights, patents and other mechanisms of control. On the contrary, there is a trend of increasing transparency, in which information produced at public expense should be made open and freely available to improve public involvement in the process of decision and policy making [8].

Many governments are currently committed to publish open environmental data. Using Big Data involves many challenges. First of all, the sheer quantity of data poses technical difficulties for obtaining and processing. Data heterogeneity, although used in "environmental knowledge integration" as an added value for decision makers as well as data-driven businesses poses a major challenge to research teams. The accuracy and precision of measurements, for instance, can be highly variable depending on the source and method. Signs of expedited climate changes, severity of extreme weather events for which classification still poses many open questions. Hence, the collected environmental data need to be shared with research institutions and the public, to take full advantages of the data. As a result, more and more environmental protection technologies will be proposed and the citizen's environmental protection consciousness will be enhanced, which will further improve the effect of environmental protection.

2.3 Air Quality Monitoring

At present, PM and O_3 are China's most problematic pollutants in terms of harm to human health. Chinese anthropogenic emissions are the most important contributors to O_3 and PM concentrations levels over China, but intercontinental transport of pollution also contributes to increased impacts on health, ecosystems and our economy (particularly crop productivity). Several air pollutants are also 'climate forcers', a term used to describe pollutants that also have an impact on the planet's climate and global warming in the short-term (decades).

Ground-level O_3, particles, and black carbon (a constituent of PM) are examples of air pollutants that are climate forcers and contribute directly to positive or negative changes in global radioactive forcing. In addition, some air pollutants have indirect effects on climate. For example, particles can also cause climate-forcing indirectly, through the changes they are causing on cloud properties, including cloud reflectivity and precipitation, and cloud formation and dynamics. The key health effects for major air pollutants of particular concern in Europe are particulate matter (PM), ground-level ozone (O_3), pyrene (BaP) and nitrogen dioxide (NO_2).

However, current monitoring methods are costly and time-consuming. And limitations in sampling and analytical techniques also exist. Clearly, a need exists for accurate, inexpensive long-term monitoring of environmental contaminants using low-cost solid-state gas sensors that are able to operate on-site and real time. Calibrated cost-effective gas sensors are a very interesting solution for networked systems suitable to monitor air pollutants in urban streets and real scenario of smart cities with high spatial and time resolution [10].

As discussed in [11], the traditional sensor materials for air quality control are different in their performance as shown in Tabel.1. We can see that the air quality directives in force require that air quality plans are developed as an additional policy instrument and implemented in air quality management zones and agglomerations where ambient concentrations of pollutants exceed the relevant air quality limit or target values. The air quality directives in force require that air quality plans are developed as an additional policy instrument and implemented in air

Table 1 Sensor materials for air quality

Sensor Technology	Sensitivity	Selectivity	Stability	Fabrication	Sensing Mechanisms
Metal Oxides Thin Films	Good	Poor	Moderate	Good	Chemisorption Physisorption Charge Transfer Catalytic, Spillover
Metal Oxides Nanostructures	Excellent	Poor	Good	Good	Chemisorption Physisorption Catalytic, Spillover
Carbon Nanotubes	Excellent	Poor	Good	Good	Intertube Modul. Intratube Modul. Catalytic, Spillover
Graphene	Good	Poor	Moderate	Good	Chemisorption Physisorption Charge Transfer Catalytic, Spillover
Conducting Polymers	Good	Poor	Moderate	Good	Chemical doping Chemical gating Deprotonation
Nanocomposites	Good	Poor	Moderate	Good	Chemical gating Deprotonation Catalytic

quality management zones and agglomerations where ambient concentrations of pollutants exceed the relevant air quality limit or target values. To ensure coherence between different policies, the air quality plans should be consistent (where feasible) and integrated with plans and programs pursuant to the directives regulating air pollutant emissions. The air quality plans may additionally include specific measures aiming to protect sensitive population groups, e.g. children. A recent pilot project, which aimed at improving the knowledge on implementation of air quality legislation, has carried out a review of the main measures adopted to manage PM concentration levels. It found that most of the measures targeted traffic emissions, e.g. the creation of Low Emission Zones; improvement of public transport; promotion of cycling; management of traffic flow; and change in speed limits. Some of the measures that were considered successful by the cities include: ensuring compliance with new low‑sculpture standards for shipping fuels in the port areas; a ban on the marketing, sale, and distribution of bituminous coal; fuel conversion in domestic heating and the creation of district heating [13].

Various analysis techniques are available for continuous chemical monitoring of criteria pollutants. These techniques include chemiluminescence, fluorescence, and absorption detection/spectroscopy (such as the nondispersive infrared analysis of CO). Such optical methods can be performed through paths of ambient air, with distinct signatures for specific pollutant. Many municipal air quality assurance systems arrange such tools into a permanent or mobile station and typically focus on a small number of criteria pollutants. The characteristics of a more general air quality chemical sensor platform, one that could see broad adoption, include the following [13]:

(1) Small size, which will allow portable, personal use or simple fixed installation.
(2) The ability to detect all the criteria pollutants down to the minimal acceptable levels set by regulatory agencies.
(3) The ability to detect a broad range of non-criteria pollutants, such as VOC’s down to the parts-per-million or even parts-per-billion level.
(4) The ability to chemically distinguish the long list of non-criteria pollutants, at least by compound class.
(5) The ability to generate alerts, and track exposure and concentration over time
(6) The ability to integrate in a data network, and to broadcast and receive data.

Some areas of invention may include, but are not limited to, the following [13]:

(1) Micro-scale air collection, separation, and sampling technologies.
(2) Miniaturized sensors using micro-technology or nano-technology, such that sensors can be integrated into small packages.
(3) Lab-on-a chip concepts and designs.
(4) Novel thin film metal oxide sensors.
(5) Electronic nose concepts with molecular recognition and discrimination.
(6) Miniaturized optical scattering and particle sizing/counting technology.
(7) Miniaturized separation/spectroscopy techniques such as GC/MS or GC/FTIR.
(8) Miniaturized optical and spectroscopic (UV, visible, IR, etc.) analysis.
(9) Chemically active FETs.
(10) Nano-wire, nano-tube, nano-particle sensors.
(11) Novel photo-ionization, particle ionization, or electrochemical methods.
(12) Sensors embedded within a device (e.g. carbon monoxide detector integrated in a cell phone).

2.4 **Water Quality Monitoring**

Before the planning of water sampling and analysis can be started, it is necessary to define clearly what information is needed and what is already available and to identify, as a major objective of the monitoring program, the gaps that need to be filled. Water quality monitoring is the foundation on which water quality management is based. Monitoring provides the information that permits rational decisions to be made on the following [14]:

(1) Describing water resources and identifying actual and emerging problems of water pollution.
(2) Formulating plans and setting priorities for water quality management.
(3) Developing and implementing water quality management program.

Table.2 Important processes affecting water quality [13]

Process type	Major process within water body	Water body
Hydrological	Dilution	All water bodies
	Evaporation	Surface waters
	Percolation and leaching	Groundwaters
	Suspension and settling	Surface waters
Physical	Gas exchange with atmosphere	Mostly rivers and lakes
	Volatilisation	Mostly rivers and lakes
	Adsorption/desorption	All water bodies
	Heating and cooling	Mostly rivers and lakes
	Diffusion	
Chemical	Photodegradation	
	Acid base reactions	All water bodies
	Redox reactions	All water bodies
	Dissolution of particles	All water bodies
	Precipitation of minerals	All water bodies
	Ionic exchange[1]	Groundwaters
Biological	Primary production	Surface waters
	Microbial die-off and growth	All water bodies
	Decomposition of organic matter	Mostly rivers and lakes
	Bioaccumulation[2]	Mostly rivers and lakes
	Biomagnification[3]	Mostly rivers and lakes

(4) Evaluating the effectiveness of management actions.

The nature and concentration of chemical elements and compounds in a freshwater system are subject to change by various types of natural process, i.e. physical, chemical, hydrological and biological. The most important of these processes and the water bodies they affect are listed in Table 2.

The effects on water quality of the processes listed in Table 2 will depend to a large extent on environmental factors brought about by climatic, geographical and geological conditions. The major environmental factors are:

(1) Distance from the ocean: extent of sea spray rich in Na^+, Cl^-, Mg^{2+}, SO_4^{2-} and other ions.

(2) Climate and vegetation: regulation of erosion and mineral weathering; concentration of dissolved material through evaporation and evapo-transpiration.

(3) Rock composition (lithology): the susceptibility of rocks to weathering ranges from 1 for granite to 12 for limestone; it is much greater for more highly soluble rocks (for example, 80 for rock salt).

(4) Terrestrial vegetation: the production of terrestrial plants and the way in which plant tissue is decomposed in soil affect the amount of organic carbon and nitrogenous compounds found in water.

(5) Aquatic vegetation: growth, death and decomposition of aquatic plants and algae will affect the concentration of nitrogenous and phosphorous nutrients, pH, carbonates, dissolved oxygen and other chemicals sensitive to oxidation/reduction conditions. Aquatic vegetation has a profound effect on the chemistry of lake water and a less pronounced, but possibly significant effect, on river water.

When a water quality monitoring program is being planned, water-use managers or similar authorities can reasonably expect that the program will yield data and information that will be of value for management decision-making. The following are examples of the type of information that may be generated by a monitoring program [14]:

(1) How the quality and quantity of water in a water body relate to the requirements of users.

(2) How the quality and quantity of water in a water body relate to established water quality standards.

(3) How the quality of water in a water body is affected by natural processes in the catchment.

(4) The capacity of the water body to assimilate an increase in waste discharges without causing unacceptable levels of pollution.

(5) Whether or not existing waste discharges conform to existing standards and regulations.

(6) The appropriateness and effectiveness of control strategies and management actions for pollution control.

(7) The trends of changes in water quality with respect to time as a result of changing human activities in the catchment area. Quality could be declining as a result of waste discharges or improving as a result of pollution control measures.

3. ROADMAP

We propose a roadmap of activities to be completed in the next years.

(1) To turn sensor data to action. Administration to be on board.

(2) Public policy coordination is needed for action to continue.

(3) Citizens need to be informed and engaged to

get the response.

(4) Environmental Monitoring points are still too costly-what is a price effective technical specification to deliver what is needed.

(5) Air pollution monitoring needs dynamic 3D sensing technology.

(6) Attracting Investors needs and to keep good quality of life.

(7) Remote sensing and meteorological models may be able to help the air pollution detecting.

(8) It is critical to distribute open data to get wider useful tool created.

(9) Success in controlling pollutants requires government support.

(10) Technology transfer issues need attention the mechanisms and need more help and communication.

(11) Calibrating a Mobile Network of Low-Cost Sensors.

4. DISCUSSION

In conclusion, we present the problems existing in Wuxi and designed a roadmap for environmental protection. As a next step, we will be focusing on state-of-the-art experimentation to fabricate the environmental protection as soon as possible so that we can start to design the implementation details for Wuxi smart city.

ACKNOWLEDGMENT

This paper reports the outcomes of the discussions had during the “Solutions and Plan of Smart Enviroment Protection in Wuxi” working group held on the Kick-off workshop for Wuxi Selected as IEEE Smart Cities Initiative, May 17-19, 2015. We would like to thank all the people who participated in the working group.

The authors would like to thank IEEE and Jiangnan University for their support in this initiative.

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