Advancing e-Government Using the Internet of Things: A Systematic Review of Benefits

Paul Brous, Marijn Janssen

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Paul Brous[1,2,*] and Marijn Janssen[1]

[1]Delft Technical University, Delft, The Netherlands
{P.A.Brous, M.F.W.H.A.Janssen@tudelft.nl}
[2]Rijkswaterstaat, Delft, The Netherlands

Abstract. The Internet of Things (IoT) has been given scant attention in e-government literature, whereas promises are high. The IoT describes a situation whereby physical objects are connected to the Internet and are able to communicate with, and identify themselves to, other devices. These devices generate a huge amount of data. When it is possible to combine data from devices and other systems, new insights may be created which may provide important benefits. In this paper we explore the expected benefits of IoT for e-governance by investigating case studies at the Directorate General of Public Works and Water Management of the Netherlands. The results show that IoT has a variety of expected political, strategic, tactical and operational benefits which implies that IoT enables effective knowledge management, sharing and collaboration between domains and divisions at all levels of the organisation, as well as between government and citizens.

Keywords: Internet of Things · e-governance · smart cities · benefits · advantages

1 Introduction

The Internet of Things (IoT) describes a situation whereby physical objects are connected to the Internet and are able to communicate with, and identify themselves to, other devices [1],[2],[3]. IoT refers to the increasing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems. These devices and the communication between these devices can benefit e-government by providing enough quality data to generate the information required to make the right decisions at the right time. E-governance is a technology-mediated relationship between citizens and their governments with respect to communication, development of policy and expressions of public will [4]. The term has very broad implications with regards to policy formulation, economic development, and the search for new ways to connect people with the political process [5]. This research explores the expected benefits of the IoT for e-government purposes by means of real world case studies.

The IoT is important because a physical (or sensor) object that is able to communicate digitally is able to relate not only to a single entity, but also becomes connected

adfa, p. 1, 2011.

to surrounding objects and data infrastructures. This allows for a situation in which many physical objects are able to act in unison, by means of ambient intelligence [6]. The object becomes a part of a complex system in which the whole is greater than the sum of its parts [7]. For example, using networked sensors and cameras to analyse traffic flow, it is possible to determine the position and length of traffic jams, and to monitor trends, variations, and relationships in the road network over time. According to Xia et al. (2012), IoT will increase the ubiquity of the Internet by integrating every object for interaction via embedded systems [8]. This will enable a highly distributed network of objects communicating with human beings as well as other objects. For example, in the Netherlands, sensors installed in buoys in countrywide network of sensors monitor the water levels in Dutch rivers and in the North Sea. The system automatically sends reports to the storm surge barriers such as the ñMaeslantkeringò and to their managers if water levels exceed the defined thresholds. Early predictions of rising water levels can be made and the storm surge barriers can be automatically closed to prevent major flooding. Also, combining information from devices and other systems using expansive analysis, may provide new insights for managers of public infrastructure. For example, it is possible to embed wireless sensors within concrete foundation piles to ensure the quality and integrity of a structure. These sensors can provide load and event monitoring for the projects construction both during and after its completion. This data, combined with data from load monitoring sensors designed to measure weights of freight traffic, may provide managers of physical infrastructure with new insights as to the maintenance requirements of the infrastructure.

Applications such as these imply that IoT has much potential; however, the benefits and barriers of IoT for e-governance, especially with regards to the management and maintenance of large physical infrastructure, have not been investigated systematically and remain largely anecdotal. There is a need to address the potentially unanticipated impacts of technology on governance structures and processes [4] and to investigate the impact of IoT in a systematic manner [9].

The methodology used in this research is described in section two. On the basis of state of the art literature and two explorative case studies at the Directorate General of Public Works and Water Management of the Netherlands, the potential benefits of IoT will be presented in section three. The Directorate General of Public Works and Water Management of the Netherlands is commonly known within The Netherlands as ñRijkswaterstaatò, often abbreviated to ñRWSò, and is referred to as such within this research. RWS is part of the Dutch Ministry of Infrastructure and the Environment and is responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. The results of the literature review and the case studies, and the expected benefits of IoT for asset management will be discussed in section four. The results show that IoT has a variety of potential strategic, tactical and operational benefits which implies that IoT enables effective knowledge management, sharing and collaboration between domains and divisions at all levels of the organisation, as well as between government and citizens. Finally conclusions will be drawn in section five.

2 Research Method

To determine the expected benefits of IoT we followed two main research steps. First the common benefits of IoT were identified from a rigorous review of literature. The keywords: ñInternet of Thingsò, ñbenefitsò (òadvantagesò), and ñe-governanceò, returned zero hits within the databases Scopus, Web of Science, IEEE explore, and JSTOR. When we replaced the keyword ñe-governanceò with ñgovernanceò, we had one hit in Web of Science and IEEE Explore, two hits in Scopus and four hits in JSTOR. The query [all abstract: "benefits" "internet of things" "e-governance"] searching between 2000 and 2015 returned ninety-eight hits in Google Scholar. We found a great deal of these articles mentioned IoT as being a potential facilitator for achieving the goal of a Smart City, but few articles mentioned how IoT would benefit this ideal. We then filtered these results and performed a forward and backward search to select relevant articles based on the criteria that they included a theoretical discussion on the benefits of IoT.

The second main research method was that of explorative case study to identify potential benefits of IoT within e-governance applications. Two cases were studied. The cases selected were both located within the context of RWS, which allowed the researchers unlimited access to subject matter experts and internal documentation for all the cases. This helped ensure the construct validity of the case studies [10]. The cases were selected based on their use of IoT for e-governance purposes ï the unit of analysis being programmes within RWS which use and develop IoT for e-governance purposes. According to the United Nations e-government survey (2014) [5], The Netherlands is an e-participation leader. This contributes to the validity of the cases as being good representations of e-governance. The cases under study were selected from different domains within RWS in order to ensure diversity and external validity through replication logic [10],[11], in which each case serves as a distinct experiment that stands on its own as an analytic unit. The domains selected were road management and water management respectively.

We studied two separate cases to refine and extend the list of benefits from literature. In the Netherlands there is a sharp divide in how processes are managed between the ñwetò or, water management domain and the ñdryò, or road management domain. We felt it necessary to select cases from both these domains in order to gain a more rounded perspective of the implementation of IoT within e-government in the Netherlands. The cases selected were: 1. Sensor information gathered for the purpose of road management; 2. Sensor information gathered for the purpose of water management. The first case deals with sensor information gathered by RWS with regards to traffic and road management. The second case study deals with sensor information gathered by RWS with regards to water and levee management. The case studies were explorative in method and descriptive in nature. Unstructured interviews were held with managers, subject matter experts, and consultants within RWS. Internal documentation was also studied. Finally, the results of the cases were shared with and verified by subject matter experts within RWS. The common benefits of IoT found in literature were listed and were compared with the evidence of benefits of IoT for e-governance found in the case study analysis. There were several iterations throughout the research as each case introduced new potential benefits. The expected benefits of the IoT for e-governance are expressed in italics within this paper.

3 Literature Background

The main enabling factor for the IoT is the blending integration of several technologies and communications solutions such as identification and tracking technologies, wired and wireless sensor and actuator networks, enhanced communication protocols (shared with the Next Generation Internet), and distributed intelligence for smart objects [1], Radio Frequency Identification technology, Electronic Product Code technology, and ZigBee technology [12]. IoT uses sensors and actuators to enable ubiquitous sensing, enabling ability to measure and infer and understand environmental indicators, from delicate ecologies and natural resources to urban environments [13]. IoT includes all devices connected to the Internet and to each other, generating sensor-based signals. By installing apps on a mobile phone or tablet the device can become a sensor in a large network. For example, accelerometers can be used to detect potential potholes when persons are cycling or driving. Cameras and microphones can be used to collect evidence when there is a robbery or a riot and devices can measure the concentration of fine particles. The resulting data from these sensors are often stored in databases. Sensors can be used for enabling public safety and compliance to regulations for example. In this way it may provide a more effective control mechanism [1, 12ï 15].

Public and private organizations are increasingly turning to the IoT as new sources of data, derived from continuously monitoring a wide range of things within a variety of situations, becomes available. These data can be used in many various ways, such as determining oneôs position or sensing the temperature to ensure that gauges are configured correctly and that temperatures remain within accepted norms. New vehicle technologies and applications can have a positive effect on traffic management systems by helping to improve the efficiency of the traffic network [16], and improving health and safety by reducing accidents and helping to reduce emissions [16], [14].

IoT results in a large amount of big data which can be opened to the public. Literature shows that this might have two important benefits for e-governance [17]. Firstly, making data and information available to the public greatly improves government transparency [17]. Increased openness and transparency helps ensure proper oversight and reduces government waste. Secondly, enabling consumer self-service in this way can empower citizens and business to take decisions through better access to information by making use of the vast amount of data collected by IoT and the collective wisdom of the crowds [1, 2, 12ï 14, 16], [18]. The IoT gives intelligent advice to users. For example, in intelligent transportation systems such as in-car intelligent driving systems and smart highways, route planning assists drivers by considering constraints related to traffic, time, and cost [6, 16].

Fleisch (2010) identifies seven value drivers for the IoT which result in potential business benefits [2]: 1. The ñsimplified manual proximity triggerò increases job satisfaction, empowers consumers by enabling consumer self-service, reduces labour costs and improves data quality; 2. the ñautomatic proximity triggerò reduces fraud related costs, process failure costs, and labour costs, and provides high granularity data for improved efficiency through process improvement; 3. the ñautomatic sensors triggerò helps improve service quality by providing individual and prompt process control, increases process efficiency and effectiveness, and provides an additional level of data quality for identifying potential areas for further process improvement; 4. automatic product security reduces cost of process failure due to fraud, reduces the cost of process security and helps increase consumer trust; 5. simple, direct user feedback improves service efficiency and effectiveness by helping processes become more accurate, more flexible, and faster; 6. extensive user feedback improves trust by ensuring new customer contact, providing new advertising opportunities and supporting additional service revenues; 7. mind changing feedback allows for the identification of trends, enabling new product features and new services, and enables an active selection of attractive customer segments [2].

Another view of possible IoT application classification is provided by Chui et al. [15] (2010). Chui et al. [15] (2010) define two broad categories for IoT applications, Information and Analysis and Automation and Control. In Information and Analysis, decision making services are improved by receiving better and more up to date information from networked physical objects which allows for a more accurate analysis of the current status-quo with regards to tracking, situational awareness, and sensor-driven decision analytics. In Automation and Control, outputs received from processed data and analysis are acted upon to improve efficiency, effectiveness and to enforce compliancy.

Haller et al. [9] (2009) draw on the work of Subirana et al. [19] (2006) and identify two major paradigms from which business value can be derived: real-world visibility, and business process decomposition. Haller et al. [9] (2009) believe that with real-world visibility, sensors make it possible for a company to better know what actually is happening in the real world. The use of automated identification and data collection technologies such as RFID enables an increased accuracy and timeliness of information about business processes and provides competitive advantages through improved service efficiency in terms of process optimisation [20]. In business process decomposition, the decomposition and decentralization of existing business processes increases service flexibility and service effectiveness, allows better decision making and can lead to new revenue streams [9]. This implies not only real-world data flows to the business processes so that they can optimize their execution, but also the capability to delegate functionality to devices. This may allow for more system flexibility in which the system is better able to react to dynamic changes [20].

In short, IoT can deliver a variety of benefits related both to the real-time measurement and analyses of sensor data as to trend analysis of historical data over time. We list the possible benefits of IoT according to strategic/political, tactical and operational divisions. This is a popular divisioning [21, 22], suitable for e-governance research. Possible benefits of the IoT are: *1. Political and Strategic - improved forecasting and trend analysis, promoting government transparency, improved citizen empowerment; 2. Tactical - improved planning with regards to management and* *maintenance, more efficient enforcement of regulations, improved health and safety measures, cost reduction; 3. Operational* **-** *improved efficiency of services, improved effectiveness of services, and improved flexibility of services.*

4 Case Studies

The goal of the case study research was to refine and extend the list of expected benefits from literature and to understand the real life benefits of IoT in the most complete way possible. For this reason, the case study research involved the use of multiple methods for collecting data. The cases were selected from the primary processes of RWS. In RWS there is a sharp divide in how processes are managed between the water management domain and the road management domain. In order to gain a rounded perspective of the benefits of IoT within RWS, we believed it necessary to select cases from both these domains.

4.1 Case Study 1: Road Management Data Collection at RWS

RWS builds, manages and maintains the Dutch national highways. Correct data is required to do this effectively. Over the years, RWS has developed several methods for obtaining the necessary data from the highways it manages, collecting, processing and making the data available to traffic and road management teams. Measurements are generally made by placing sensors in the road in many different locations. These sensors produce large amounts of data which is mainly used in *mid-term planning*, *long term projections*, air quality predictions and noise calculations which have an impact on *health and safety measures* as well as the *environmental impact*, and improving *service efficiency* with regards to road works management.

During the winter months, RWS performs preventive scattering of salt on the highways to ensure that highways remain safe to drive on. Salt lowers the freezing point of water, thawing snow or ice. The nationwide slipperiness alarm system (SAS) automatically alerts RWS when potential hazardous situations arise with regards to the slipperiness of the road surface. SAS measures, among other things, the temperature of the road surface, air humidity and the salinity on the road. RWS decides whether or not to scatter salt based on the information provided by this system. This decision also takes into account the weather and the amount of salt that is possibly already under way. The improved efficiency and flexibility of this system means that only two hours are required before salt is scattered on the roads. Furthermore, the system contributes to the effectiveness of the service by helping RWS scatter salt in the correct places.

At present, RWS estimates that at least 15 percent of freight traffic on the Dutch national road network is overloaded. Overloading of heavy vehicles causes road pavement structural distress and a reduced service lifetime [23],[24]. Effectively reducing overloading reduces the damage to the road infrastructure, lengthening the roadȏs lifetime and reduces the frequency of maintenance. RWS has to deal with the negative effects of overloaded freight traffic. The damage to pavements and installations by overloaded trucks in 2008 was estimated to be at least 34 million euros per year. In addition, the extra maintenance required creates a significant amount of traffic disruptions. These disruptions are estimated to cost several million euros per year. The ambition of RWS is to increase the effectiveness of the approach of overloading. In 2010, RWS decided to tackle the overloading problem through structural cooperation. This decision was recorded in a protocol to reduce the current rate of infringement of overloading from 15% to less than 10%. Based on this objective, the estimated annual reduction in maintenance requirements of the damage to structures and pavements was calculated at a magnitude of 11 million Euros per year.

To facilitate enforcement of regulations, and reduce costs, RWS has created a national network of monitoring points, the ñWeigh in Motionò network. This network, consisting of measurement points in the road on which the axle loads of heavy traffic is weighed, is used to support the enforcement of overloading by helping the enforcement agency to select overloaded trucks for weighing in a static location. In addition, the enforcement agency collects information regarding each truck. This provides access to the actual load of the main road, about peak times when it comes to overcharging and it provides RWS with the ability to collect information concerning the compliance behaviour of individual carriers. This forms the basis for business inspections and legal follow-up programs. According to RWS, the critical success factors for the deployment of the ñWeigh In Motionò network are the strategic choice of locations and weighing the reliability of the measurement points. This tool has proved to be very effective in addressing overloading, especially because of the perception of probability and the enhanced effect of enforcement.

Inductive loops embedded in the road surface remain a key technology for traffic detection. An inductive loop is a simple and reliable way to detect the movement of vehicles over a road surface and is extensively used in traffic responsive traffic signal systems to collect traffic data to optimise signal timings accordingly [16]. Such loops provide data on traffic density, flows and speeds for trend analysis as well as providing a key input to real-time traffic models which predict queues or delays. RWS has implemented a system of induction loops for monitoring traffic flows. Traffic signalling is indicated by Motorway Traffic Management (MTM) and is installed on several highways in the Netherlands. MTM is a fully automated network management system and is used for automatic incident detection (due to road works or situations regarding defective infrastructure, for example) in order to improve the efficiency, effectiveness and flexibility of the services provided, as well as the enforcement of speed infractions and other control measures.

Traffic congestion is a major problem in the Netherlands. Recent years have seen a shift towards tackling the problem by managing the existing capacity rather than the traditional concept of more road building [16], requiring more efficient traffic management tools integrated within a wider traffic management environment. Within the Roads to the Future programme, RWS is undertaking a pilot project called 'Guide on the road' [25]. The pilot project 'Guide on the road' is looking to develop a system in which the motorist is presented with all the relevant road information in their car in real time. This system will collect data from various sources, process and manage the data and use this information to implement various measures to manage traffic. In its ultimate form, this could lead to a situation in which there are no road signs or other physical media along the way ï the ñSmart Highwayò. All information such as (maximum) speed limits, parking opportunities, the next gas station, passing zones and current route information is delivered directly to the motorist, in the car, in the form of picture, text or sound. The system provides driving assistance in the car, from warning for sharp turns, to traffic (management) information. RWS is attempting to develop and test the concept of the Smart Highway on the basis of a pilot study with regards to the usability and deployment aspects of these technologies.

Improving safety by reducing accidents is one of the spearheads of RWS. According to RWS, more than 12.5% of all traffic jams on Dutch roads are caused by accidents [26]. Improving traffic safety can in this way also make a direct contribution to reducing congestion, which improves the efficiency of the road network. Accidents and traffic jams are often caused by unsafe driving practices such as tailgating and speeding. Traditionally, traffic management practices have focused on enforcing regulations. Within the ñRoads to the Futureò programme, RWS are also investigating how rewarding desired behaviours (as opposed to enforcing compliancy) such as keeping a safe distance and complying with the applicable maximum speed improves the behaviour of motorists. In cooperation with business, RWS has developed a field trial in which participating lease drivers are rewarded for good behaviour. Driversô behaviour is recorded by a system in the car. This system includes a display which provides continuous feedback to the motorist while driving with regards to his following distance and speed. RWS expects that this approach will have a positive effect on road safety and traffic flow.

The expected benefits of the IoT for road management identified within this case are: *1. Political and Strategic - improved forecasting and trend analysis, promoting government transparency, improved citizen empowerment; 2. Tactical - improved planning with regards to management and maintenance, more efficient enforcement of regulations, improved health and safety measures, and cost reduction; 3. Operational - improved efficiency of services, improved effectiveness of services, and improved flexibility of services.*

4.2 Case Study 2: Water Management Data Collection at RWS

In the innovative ñLiveDijk Utrechtò project RWS, water board the Stichtse Rijnlanden, The IJkdijk Foundation, and the Province of Utrecht are working together to develop knowledge and experience gained by the application of sensors for the inspection and testing of levees (smart levees) in levee management [27],[28]. The major benefit identified by the project is that the smart levee philosophy will lead to significant *cost savings* and deferred investments for water management authorities in the Netherlands. In its supervisory capacity the Province of Utrecht is already using knowledge gained by these tests for improving the *efficiency* of integral water management and water *safety*.

In The Netherlands, levees are inspected at regular intervals, usually two to three times a year and more frequently at high tide. Drought sensitive levees such as the Grechtdijk are inspected more frequently in periods of drought [27]. Traditionally, these are visual inspections of the external levee walls. This task is time consuming and provides little information about the internal conditions of the levees. According to the IJkdijk Foundation, sensors have been buried in the Havendijk levee in Nieuwegein and the Grechtdijk levee in Woerden. These sensors continuously monitor the water pressure in the two dykes. The more water a dike absorbs, the more the sand and pebbles can move the weaker the dike becomes. The water pressure in the embankment is therefore a measure of the stability of the embankment [29].

The sensors embedded in the levees supply a wide range of data. This data is centrally stored and used for the real time visualization of the measurements in a dashboard displaying the sensor results. The data is then directly interpreted for detection and warning systems. These sensors are increasingly being used for the management and monitoring of water barriers. This has resulted in a huge growth in the amount of (digital) data collected for this purpose. With regards to the LiveDijk programme, the participating organizations have ensured that the data is available for distribution via the Dike Data Service Centre, which is managed centrally by the IJkdijk Foundation [27]. The Dike Data Service Centre is a platform built up around a national database for the storage of measurement data in and around dikes and water barriers. This involves both real time and historical data. Linking the data of several levee management organizations makes it possible to compare the data of similar dikes in time. Examples of data that is measured include: height measurements, subsidence (in x, y, z direction), water and ground water levels, soil saturation, temperature, infrared and radar scans.

The National Water Measurement Network, at RWS known as ñLandelijk Meetnet Waterò (LMW), is a facility that is responsible for the acquisition, storage and distribution of data for water resources. LMW has more than 400 data collection points using a nationwide system of sensors. The data is then processed and stored in the data centre and is made available to a variety of systems and users. The LMW was created from the merger of three previous existing monitoring networks: the Water Monitoring Network, which monitored inland waterways such as canals and rivers; the Monitoring Network North, which monitored North Sea oil platforms and channels; and the Zeeland Tidal Waters Monitoring Network which monitored the Zeeland delta waterways. Four main types of measurement activities can be identified: water quantity, water quality, meteorological data and control information on infrastructure. The LMW measures a wide variety of hydrological data such as water levels, flow rates, wave heights and directions, flow velocity and direction, and water temperature. The LMW also measures meteorological data such as wind speed and direction, air temperature and humidity and air pressure amongst others. This meteorological data is collected in close collaboration with the Dutch Royal Meteorological Institute. The LMW provides a complete technical infrastructure for gathering and distribution of data and delivers the data to various stakeholders within and outside RWS. This distribution of data greatly improves the *transparency* of the decisions and actions taken by RWS such as when to close the storm surge barriers. This decision has a major impact on the Dutch economy, as it means closing access to the Dutch harbours.

The LMW is essential for the *efficient* management of the primary processes of RWS, especially with regards to water management (including the regulation of water levels), *planning* of construction, management and maintenance of infrastructure, improved efficiency, effectiveness and flexibility of shipping management and improved enforcement of regulations, more detailed weather forecasts for shipping and aviation, more efficient and effective warning services and improved *long term trend analysis*, such as rising sea levels. An important use of this sensor data is for the management of the storm surge barriers with regards to *safety*. Storm surge barriers are movable dams in estuaries, waterways and estuaries. They protect sensitive areas from flooding. RWS water defences are huge, imposing structures that protect The Netherlands at high tide. The LMW makes it possible to automate this process based on accepted norms and using well tested models, greatly reducing the time required to act in emergency situations. The LMW data is also used by, among other things: hydro-meteo centres, municipal port companies (including the Port of Rotterdam), storm warning services, energy corporations, meteorological institutions, and flood Information and warning systems.

The expected benefits of the IoT for water management identified within this case are: *1. Political and Strategic - improved forecasting and trend analysis, promoting government transparency; 2. Tactical - improved planning with regards to management and maintenance, more efficient enforcement of regulations, improved health and safety measures, and cost reduction; 3. Operational - improved efficiency of services, improved effectiveness of services, and improved flexibility of services.*

5 Discussion

The objective of this research was to identify potential benefits of the IoT for e-governance purposes. The IoT is important because a physical (or sensor) object that is able to communicate digitally is able to relate not only to a single entity, but also becomes connected to surrounding objects and data infrastructures. This allows for a situation in which many physical objects are able to act in unison, by means of ambient intelligence [6]. These devices and the communication between these devices can benefit e-government by providing enough quality data to generate the information required by government and citizens to make the right decisions at the right time.

We used two main research methods: (1) a literature review, (2) an analysis of two data infrastructure case studies. The literature review provided us with an overview of the existing body of knowledge, allowing us to analyse where gaps in knowledge or focus occur. It also provided definitions for the key concepts and helped develop a broader knowledge base in the research area. Case study research is a widely used qualitative research method in information systems research, and is well suited to understanding the interactions between information technology-related innovations and organizational contexts [30]. Following the advice of Yin (2003), the protocol used in the case study included a variety of data collection instruments. In order to counter the possible influences of bias, multiple research instruments were employed to ensure construct validity through triangulation [8].

The results of the literature review and the case studies demonstrate that the IoT provides a variety of expected benefits with regards to e-governance which correlate with benefits identified in the literature review. Table 1 below lists the main benefits of IoT, differentiating between strategic, tactical and operational benefits.

Table 1. Benefits of IoT for e-governance in relation to the case studies.

	Benefits	**Case 1**	**Case 2**
	Improved forecasting and trend analysis	✓	✓
Strategic	Improved citizen empowerment	✓	
	Promoting government transparency	✓	✓
	Improved planning with regards to management and maintenance	✓	✓
Tactical	More efficient enforcement of regulations	✓	✓
	Improved health and safety measures	✓	✓
	Cost reduction	✓	✓
	Improved efficiency of services	✓	✓
Operational	Improved effectiveness of services	✓	✓
	Improved flexibility of services	✓	✓

Strategic benefits exert a decisive influence on an organizationôs likelihood of future success. Formulating strategy requires defining major goals and initiatives based on consideration of resources and an assessment of the internal and external environments in which the organization competes [30]. IoT provides a continuous stream of ñtrustedò data which managers can use to make informed, data-based decisions based on reliable forecasting and trend analysis. But although sustainable development has changed significantly over the past decades [5], RWS is still largely organised in ñsilosò, in which departments and their managers tackle issues through a domain related perspective as opposed to a collaborative one. At the same time, Dutch citizens and businesses are demanding more open, transparent, accountable and effective governance. The case studies suggest that IoT is enabling effective knowledge management, sharing and collaboration between domains and divisions at all levels of the organisation as well as between government and citizens. This has improved the empowerment of citizens as well as promoting government transparency helping to improve the inclusivity and accessibility of government services provided by RWS.

Tactical benefits assist the administrative process of selecting among appropriate ways and means of achieving a strategic plan or objective. Tactical planning is short range planning that emphasizes the current operations of various parts of the organization [31]. Obtaining field information primarily through manual measuring experience or judgment in requires extensive labour costs and data quality is often low. The case studies back up suggestions made by Chen et al. [12] (2012) that collecting information accurately and in real time allows managers to exploit resources reasonably, reduce production costs, improve the ecological environment, and improve products.

A primary use of IT in government is to improve the efficiency of government operations [17]. As with many other organisations [2] RWS uses IoT as a tool in industrial automation, in which simple manual tasks such as opening and closing bridges are automated. This reduces very low-level coordination work that was previously executed by humans. In this regard, IoT reduces the cycle time of the operational management ñDemingò cycle [32] at RWS. This allows a continuous comparison of actual values with expected norms and enables the early detection of faults such as suggested by Fleisch [2] (2010). Constant checks such as those performed by the ñweigh in motionò system at RWS, enable information systems to automatically detect relevant events. This allows RWS to manage operations by exception, in which systems deal with various known situations independent of human intervention. IoT is also important for quality of government services as suggested by Castro [17] (2008). IoT improves the quality of RWS services through improved effectiveness, such as that displayed by the distribution of salt on slippery roads, and improved flexibility of services such as that of the LMW which is able to deliver data for a wide variety of applications.

6 Conclusion

The IoT makes it possible to access remote sensor data and to monitor and control the physical world from a distance. Furthermore, combining and analysing captured data also allows governments to develop and improve services which cannot be provided by isolated systems. This paper represents one of the first papers on IoT and e-governance. Although there has been limited research in the field of e-government about IoT, there is much potential as expressed by the potential benefits. This research provides a systematic insight into the expected benefits of the IoT for e-government purposes by means of case study analysis and a review of literature. The research shows that benefits range from the political to the operational level. Specifically benefits for e-government can be attributed to improved efficiency, effectiveness and flexibility of services; reduction of costs; improved citizen empowerment; improved government transparency; more efficient enforcement of regulations; improved planning and forecasting; and improved health and safety measures. It is clear that IoT will have a major impact on e-government services in the future and will bring a variety of benefits for e-government at all levels. However, potential barriers and negative influences of the IoT for e-government remain unclear and we recommend more research on addressing these issues.

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