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IMPLEMENTABLE APPROACH OF ADDRESSING THE CHALLENGES OF CLOUD BASED SMART CITY USING IOT

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ABSTRACT

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Implementation of IOT in smart city is a complex issue which requires advanced networking and communication technology and specifically cloud based technology is required. In this paper we introduce the general notion of IoT hubs and then Propose an algorithm to address the challenges faced to implement cloud based SMART Cities. We addressed two issues, one with integration of public and private cloud and another one ability to handle and exchange the data easily. This paper briefly describes an approach to address these issues and discuss about deploying cloud-based Smart City hubs.

1. INTRODUCTION

Significant research into the technologies needed to support implementation of IOT Based Smart Cities has been carried out recently with a focus on using information and communications technologies to manage city infrastructures like Monitoring the pollution, Monitoring the traffic and transportation, energy monitoring and Structural monitoring. Nowadays the research focuses on specific platform to use IOT effectively with integrated approach. So Internet of Things plays important role in Smart City deployments. Both the government and private together participated for Initiating Smart city projects. e.g. IBM, Cisco and Living, et al. [1] reference initiatives like the IoT-A [2] and large-scale urban test beds e.g. [3-5].

So Paper focus on approach using Cloud Based IOT “hubs” that provides an easier accessing of data and transfer with the available infrastructure in the city. In this Cloud based hub the data and real time information which is sensed from the sensor deployed is available to all the citizens and easy to use for further application purpose. In this paper, We presented detail on Centric Based approach for IOT implementation and the architecture is cloud based approach and discussed about applications to support Hybrid Cloud infrastructure [5].

2. LITERATURE

The IOT design, implementation and use it in Smart Cities is integrated approach and a complex one also, and it depends on various research issues ranging from sensor networks to open-data portals. Some of the examples are the use of sensor in traffic applications such as magnetic sensors and other scanners to implement and assist the

traffic operators [6]. Experiments like real-time monitoring of critical infrastructure such as the urban water supply [7] to buildings allows smart-grid to interactively manage energy use for the city [8]. This integration and deployment with the traditional infrastructure sensing is the main goal of cloud and even with the help of social networks [9, 10] and mobile phones [11, 12].

The advanced use and available data stream technologies with the centric approach will fetch additional solutions and address the drawbacks of the urban sub-systems. So the need is data exchange and availability gives huge handling and hence the integration of smart city systems with available technology and it requires open innovative platform to accommodate the above systems on a large scale networks[13]. So this paper explores the use of cloud based technologies as the basis for open platforms [14, 15].

In this paper, it is addressed how to build and scale a cloud-based IoT platform which can be used across a large scale research and as a central approach to build a urban-scale IoT systems.

A. IoT Hubs for Smart Cities

The use of Cloud computing with IOT gives a centric framework for Smart city implementation and also this paper addresses the two issues discussed. First issue is to use the available technology integration with the emerging IOT structure, so that the system and application developers will use easily the deployed system.

Then the second is usage of cloud computing to implement smart cities can integrate a number of sub-systems that make up complete Smart city Infrastructure [16].

In addition to the deployment of infrastructure as well as management, hubs from cloud based offers a framework to integrate both static and real time urban data sets from private and public parties. The main problem here is the delivery of data and exchange of data, so hubs acts as interface portal for all types of users from primary to end users. Another advantage is easy to use the service provided and available to common man with accessing the nodes easily.

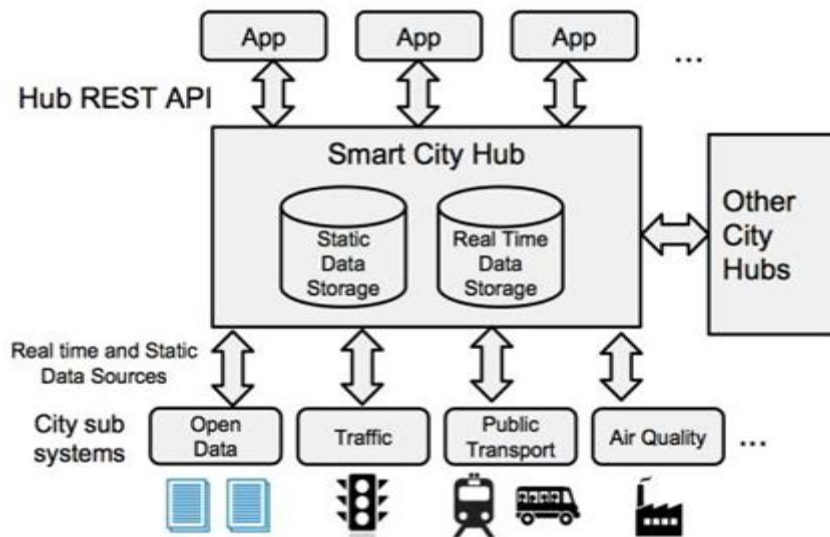


Figure-1. An IoT hub acts as a portal for Smart City Infrastructure as well as other hubs.

The hubs deployed in the infrastructure has integrated and dynamic data which can be used for easier accessing and also for different applications depending on the current or expected conditions.

Integrating the data in the hub can be used to aggregate many systems connected to it and functional wise the data integration and easier and minimal maintenance is required. Otherwise the individual sub systems required special attention. Many hubs connected to a single primary hub will easily create reusable applications that work in multiple cities and required only primary station to control entire scenario.

B. Cloud Considerations

The proposed Centric based Smart city hub has easy to use access point for the input data and usage of data has a number of complexities which depends on the services provided and infrastructure.

1. Hybrid-Cloud requirements. It is not possible to build a single Hub for entire smart city and connect to cloud. Instead with the private networks which controls traffic to sewerage etc. Once cloud based IOT is deployed the infrastructure completely migrate to public cloud infrastructure and addresses hybrid public-private cloud.

2. Cloud-Cloud or Integrated Cloud. The second important issue is Integration with the cloud. So this issued has to be addressed since the city infrastructure is generally a system based approach with a number of temporary services with respect to different aspects of a smart city. In some cases the single framework will work but with respect to different aspects Cloud integration is required. So after cloud integration the new services will ensure smoother and easier functional operations comparing to non integrated approach.

3. Hub-to-Hub interoperability. Once Multihub is deployed there is a need for hub to exchange data among themselves. So cloud based smart city needs standardizations. There is need to propose common based approach with concrete representations for implementing Smart City hubs. This will include security mechanisms, control access to hubs and Source data for interoperability.

3. DATA HUBS

A number of IOT and cloud based Smart city technologies are in the market with different focusing depending on the specific applications. In this paper we consider on Highway Infrastructure focusing on roads and sensors for Smart City implementation.

A. Smart Streets

The idea proposed in the paper mainly the use of cluster heads and its representation with respect to smart city. Once the cluster is formed and then the area coverage within the city for example government buildings, schools, airports, transportation hubs etc can be integrated.

In this paper the data from variety of sources like national and regional network from GPS and Control room is gathered to do work related to processing to maintenance of Highways. The data which is received is real time traffic data, incident related to traffic flows, flood, sensor datas etc are made available through the implemented SMART HUB. A protocol is developed and presented in this paper for IOT Hubs for Highway maintenance. [Hyper \[17\]](#); [Josh \[18\]](#).

B. Common Urban HUB

The Common Urban HUB to foster the development of innovative Smart City applications, involving a mix of citizen, government, private sector, and infrastructure data. The Urban Hub provides data storage and easier point of access to the data sets stored commonly. So API developers can use it easily with simple architectures with real time data and also static data.

C. Core IoT Services and City Centric Data Flows

The main drawback of the projects is need to collect a diverse set of existing data sources like traffic data, water level data in the road, network schedule, highway signs data, bridges data in IOT Hub. This requirement helps in improving IoT platform with real-time systems and also with the control of infrastructure nodes which integrates and gives easier accessing. The application data are captured in static files stored in Main urban hub. Any smart city platform needs to be able to handle these and make them available in some form to developers.

An IOT platform is designed to support data for both static and metadata storage and this IOT core is shown in Figure 2.

3.1. Managing Real-Time Sensor Data

The IOT kit is centric based approach kit and it focus on managing things in real time behavior. A set of IOT Services is possible through proposed API's and web based application will be developed

. Through web based applications Control command can be developed and control over the data with API is easily achievable. Sensor data is a mix of scalar and text values and handling through the proposed ideas become much simpler. Sensor data can also associated with metadata to facilitate search purposes. The platform is sensor based and feeding and tapping from the network of sensor is same as that of social network i.e. same as that of connecting to twitter or face book.. The IOT kit includes user interface for viewing sensor data using customizable alerts with real time environment working [19]; [20].

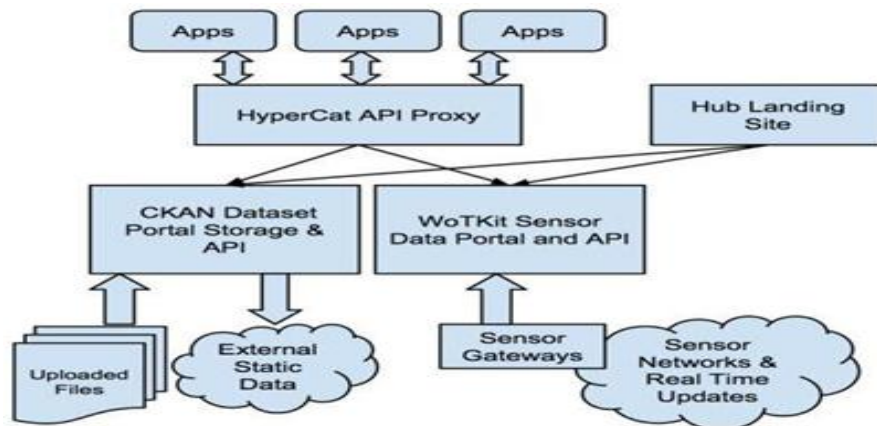


Figure-2. The core IoT infrastructure supports access to real-time and non-real time urban data streams.

3.2. Managing Static Datasets

Data with the sensor network and managing is a critical process and hence data management system and portal that allows data publishers like public and private organizations to make their data available to others. It allows data publishers to easily upload and publish new datasets. Data Management set provides an API allowing developers to search for data within relevant datasets. We can use Data management software system to store data sets that are static or dynamic.

4. CITYHUB

First a Smart City Hub Framework has to be formulated using IOT Framework and using this third party easily can deploy their own smart city applications using IOT. In turn these parties provide services for local authorities and also for national hub or connect to Cloud hub to manage and interface the implemented Infrastructure. IOT Data hub is the core of the City Hub that provides API and its access for managing and controlling the data streams. From figure 3, the Hub API provides some capabilities for access and control of infrastructure. This layers forms a cloud service layer on IoT framework which is available for application developers. This offers multiple application providers to start the services and manages the available resources with the designed platform. The service request and constraints can be managed by the new paradigm Lifecycle management that governs and maintains the platform effectively. Then usage maintenance and billing capability is used to find efficient usage of resources provided and charged according to that rules defined for the end customer.

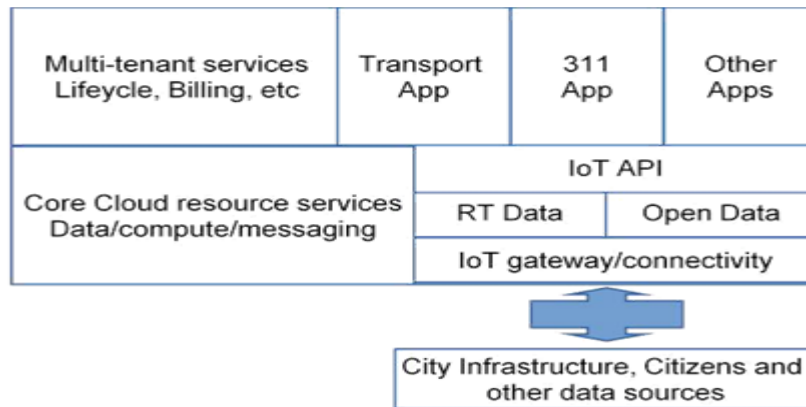


Figure-3. An IoT centric framework for Smart Cities

The new Application and service developers use this available cloud infrastructure to start the new services within the available framework and also giving rights to access the IOT API and other services. The centric IOT framework components offer this and provide service end points to the customers.

For example the use of Smart City service likes traffic/transportation which provides end users information on the status of the city’s road, rail and bus network. Such an application would use data from a variety of city sources from transportation or any others services from social media. So data nature is huge and wide and usage depends on the end user. The implemented APP will update the status of the citizens on transportation, route sharing, real time advice and routing and sustainable management sharing on transport like services to end user within the available framework. Cloud services are used in urban areas with the management software and hence the core data hub gets information from a variety of data feeds and would be managed efficiently.

More common examples of these include popular mobile apps with the google to set the street through GPS. These applications are defined as managed application within the City Hub, but they will interact with city services running on City IT infrastructure. One approach to this exploits is that the fact that in many cities are moving towards an open framework that provides a single interface to city services. The services provide easy interface with the web browser or smart phone and service request is routed properly through the city hub. Open framework offers a well-defined API for web based and also can be common based service to end users. Interestingly, in cities it would be possible to host the open framework in a City Hub with even distribution of a city service between the private and public cloud.

5. CLOUD BASED CITYHUB

In previous sections we introduced hybrid cloud, cloud-to-cloud and general hub interoperability issues. Of these, we developed an IOT framework and integrate with cloud issues remain an area for future work.

A. Hybrid Cloud and Application Partitioning

Any cloud platform designed need to address the complex set of existing services which includes the available and new infrastructure for smart city implementation.

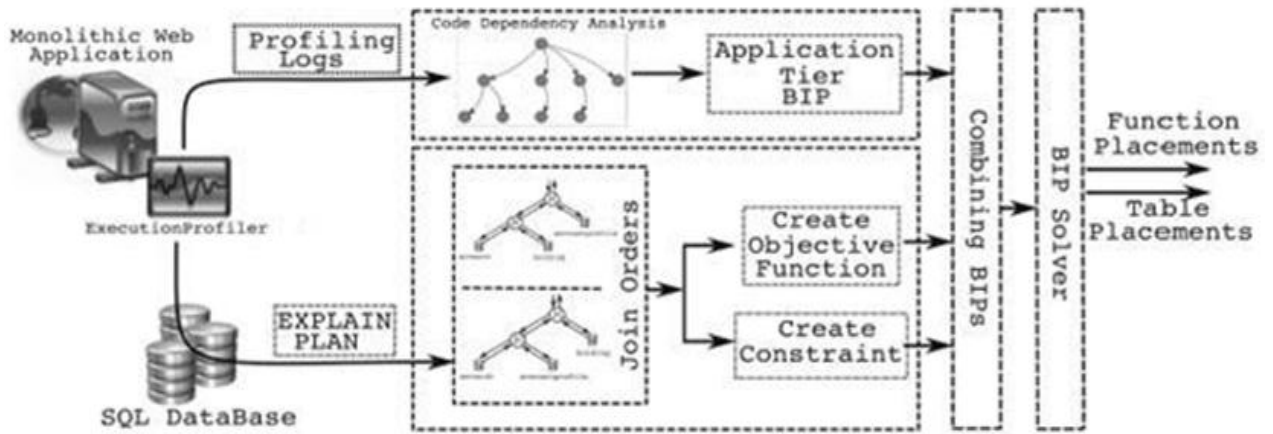


Fig-4 a monolithic web with IOT Framework

Figure 4 shows the monolithic web based IOT Framework and it is a cloud based for efficient management through the software management systems. The proposed hub architecture is able to support Hybrid cloud for smart city applications and services act on both public infrastructure and private cloud infrastructure. The open frame work sevices offered here can be moved or migrated to public cloud for cost and performance reasons. If security issues raised then backend services can be in CITY hub for efficient handling. To support this scenario we have explored application partitioning for hybrid cloud [21, 22] with a particular focus on combining code (application) and data partitioning. To address partitioning, we follow the methodology shown in Fig 4. The execution time is measured on a reference and the data is collected between the entities and functions defined for the data. A dependent graph is produced which can be analyzed to examine the effects cost models and any type of constraints. Finally, the obtained graph can be converted into an optimization problem and solved using binary integer linear programming (BIP).

The main interest of the paper is to partition the algorithm with cost models by public cloud infrastructure. Specifically, we have developed a flexible approach that allows City IT planners to explore the cost implications of moving service and application code from private on-premises to public cloud which often has significantly lower costs. The literature shows that asymmetric model is used for much public cloud for modeling the data with lower rate. Our partitioning algorithms allow for the exploitation of this and other aspects of cloud cost models as developers search for the correct trade-off between performance and cost. The aim is to balance the need to maintain the privacy and use low cost public infrastructure.

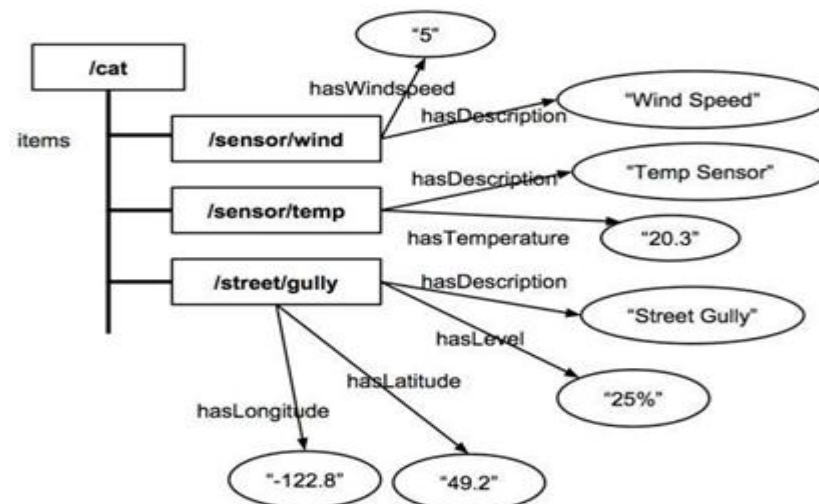


Fig-5. HyperCat catalogues consist

```

{
  "metadata": [
    { "rel": "urn:X-tsbio:rels:isContentType",
      "val": "application/vnd.tsbio.catalogue+json" },
    { "rel": "urn:X-tsbio:rels:hasDescription:en",
      "val": "Bare catalogue" }
  ],
  "items": [
    { "href": "http://hub.com/resource1",
      "metadata": [
        { "rel": "urn:X-tsbio:rels:hasDescription:en",
          "val": "The first resource" }
      ]
    },
    { "href": "http://hub.com/resource2",
      "metadata": [
        { "rel": "urn:X-tsbio:rels:hasDescription:en",
          "val": "The second resource" }
      ]
    }
  ]
}

```

Fig-6. Example HyperCat catalogue.

In our initial experiments, we have seen cost savings of upto 40% for typical 3 tier applications as we have deployed across public and private cloud. Full details of our approach to Hybrid Cloud partitioning can be found in [Kaviani, et al. \[22\]](#).

B. Data Transfer and Communication Issues

The another area noted is the data issues i.e communication and exchange between the framework and providers as it relates to the data and control (or IoT) aspects of their platform. For this case of data exchange or transfer there is a need for applications to make use of multiple hubs which can be used for Urban areas. Here the corporation with the municipalities and local governments services are assumed. Now common Framework API will be developed which can be adopted by main hub or corporation etc and follow on it is possible to define a subset of the API with interface with main hub. Also Both main and subset will be focusing on the IoT resources, control and its management. The defined subset will focus on allowing a hub to expose the IoT resources and managed through a well defined rules and then provide other hubs, or external applications, to query and search for data managed by a hub in a common way.

We referred the HyperCat specification as in [Hyper \[17\]](#) developed by the 8 consortia. HyperCat specifies a catalogue and queries on the rules available on the web. Exposed resources are described to provide information about the format and semantics statements as shown in Fig. 5. This enables applications to search for suitable resources and understand the data when they retrieve it. Due to this it is easily describe the resources and easy query on the applications interested by the users. [Blackstock and Lea \[23\]](#).

We developed an *API* which provided a unified HyperCat catalogue with both static and real time data sources in the hub. An example of the result of a call to the API is shown in Fig. 6.

6. IMPLEMENTATION

SMART City hubs are deployed for many applications. The hubs are deployed on different cloud services, with the hub running on the existence. Of the two hubs, Smart Streets has slightly longer and assuming sensor feeds and a wide variety of static datasets. The data may be traffic data, flood data, road data, air quality environmental data weather data etc. These data sources have been pushed into the hub either via tools that harvest data from the web,

by end users uploading data sets, or from physical devices, explicitly sending information to the Hub via APIs.

It is possible to find and install hub applications in the app store to list the featured applications and provide for easy search.

Applications developed for the Smart Streets Hub have included a “Catalogue Explorer” to browse not only our hub catalogue, but that of the other seven hubs. The subset application called Roadwork is developed and control and visualize correlations occurring between the drain blockage in sewage and road works.

Another application is GC which extracts data from sensor to repair road and gully levels. It also ensures to find the similarities related work to understand the city drain and the need for other services. Another app is finding holes in the roads call PP for hole analysis on the roads. Pedestrian cross, Sub road classify, size of road etc can be developed. Also ‘Street Trees’ to access and contribute data to a database about urban forest.

The Urban app ‘Vehicle rack’ Application gets the vehicle rack inventory of the city to display locations where vehicle safely park in the allowed location. The Hub can be connected with the locations and also with the application, including where and when users search for parking and routing. Using this data, authorities can effectively maintain and control the traffic, road work and other issues easily.

7. OTHER IOT WORKS

Platforms for unifying IoT resources for a Smart City have been the focus of several Smart City test beds [15, 24]. IoT hubs and large-scale sensor networks have been used for making a variety of data streams from the physical environment available to application developers [19, 20].

The Smart Santander test bed includes a platform for experimenting with a variety of IoT technologies. The aim of the system is to address the homogeneity and heterogeneity issues in IOT [5]. The test bed deployed in Oulo, Finland [4] aimed to provide systems infrastructure support for application developers of public space services via a set of middleware tools. The City Sense test bed provided a city-wide platform to enable large-scale sensor and wireless networking research in a real-world urban setting [3]. While all of these systems provide centralized platforms, they did not aim to provide a cloud-based hub acting as a centralized access point for accessing both sensor data and data streams were not focused on offering a city focused IOT Framework.

Large-scale IoT hubs allow web developers to integrate ‘things’ across a wide variety of domains. The WoTKit [25] as well as Xively [19] aggregate collections of data streams called feeds to store information about sensors and the data they emit over time. Similarly, Thing Speak [20] supports a hierarchically data model of channels with data feeds. This helps in processing, visualization and integration of data and allowing others to take advantage of the integration work of others. Each of these platforms offer a ‘hub’ model to provide a repository for ‘things’ (data and metadata) and a set of APIs for accessing and using ‘things’. These hubs do not focus on supporting Smart City applications per se., and while they do support real time data streams typically do not support static data set management.

The IOT framework is proposing an architectural reference model with key components of the future IoT to enable search, discovery and interaction of data within then network [2]. The work proposed has easier approach to build IOT platform at larger city scale than single access or a small area platform and also concern about data accessing for whole city. The IOT Platforms focused on smart city includes Open IoT project [26] as well as Lee, et al. [8] and Cloud T [27]. The discussed projects have some draw backs and it has nothing expressed about data sharing transfer and hybrid cloud deployment.

8. ISSUES ADDRESSED

When designing the network and creating API for our framework identifies number of issues related to cloud and proposed model..

Hybrid Cloud: The Partitioning problem of area for active cloud is an active research area. In our work we

have focused on multi web applications. Initial proposed design shows the significant improvement and our approach allows the tradeoff between cost and security. However, we have noted two areas where our work could be extended to adapt to current practices in city IT departments. Initial the constraint in resources or even skills to handle the partitioning of area is major concern for implementing our approach. It is better to use the methodology of coarser grained partitioning in the server appropriately. So such circumstances we can use our methodology and we never use partitioning approach. Then work is based on web applications that follow a standard model with IT applications.

Hub architecture and APIs: The main focus here is to create common catalogue in Creating Smart City Hub with easier data access and sharing IOT resources and data to be diverse set of data and availability. Making a diverse set of data sets and IoT resources available on a hub with a common catalogue is the main focus in the proposed work. Even within the limited scope of the Hyper Cat specification we found that integrating the proposed frameworks systems was difficult. Some of the challenges included, the need to resolve different access control mechanisms, different query semantics, and dealing with large datasets and data catalogues. Based on this experience with Hyper Cat, and how hub data feeds, and the diverse data already available on the web, it may be more practical to agree on how to describe domain-specific data formats rather than agreeing on one format. Using a data format agnostic catalogue like Hyper Cat with a flexible metadata facility for describing both static data sets and IoT resources will allow developers to decide whether they can use data from the resource available.

9. CONCLUSIONS

Implementing the cloud based hub using IOT for developing Infrastructure in smart city is main and core of the proposed framework. In our work we have focused on the IoT and Smart Cities and used our IoT hub as a platform and test bed for two deployments. Our architectural approach has core IoT with data hub and proposed framework. The proposed idea addresses core technical issues in building cloud-based IoT frameworks for smart cities. One significant advantage of this approach is that multiple hubs can be connected to build up a system which represents significant parts of the IoT ecosystem. We have demonstrated some of the advantages of this approach through our proposed framework and number of applications and services developed for the hubs.

There are two areas that we feel require further work, firstly the area of integrated cloud and secondly the area of application development.

Integrated Cloud: With respect federated cloud, our initial experiences have shown that we need to accept the reality of existing city infrastructure. The proposed work proves the application partitioning for hybrid cloud is aimed at addressing all the constraints specified. A second major issue is the fact that as new cloud infrastructure becomes more frequently used, we will see an increasing number of smart city cloud offerings. It will be necessary to ensure that our cloud based smart city hub is able to accommodate a number of framework services and that we can offer application developers to exploit available services and functionality resident in other clouds.

IoT application development tools: IOT Application development is the critical issue and much development required for adaptation. But in web based applications, IoT applications, by necessity, often require code to run at infrastructure end points. To rectify this we need an application framework which is available for end devices. To address this issue we have begun extending our application development tool for proposed framework [25]. This tool provides a visual programming tool that allows IoT application developers to 'wire-up' data sources with processing logic and outputs (in a similar manner to Lab VIEW or Yahoo pipes). We plan to extend our tool to allow code components to be migrated not only to private cloud, but also to end nodes also. Our approach looks to combine some of the benefits of our own processor with other IOT resources.

Clearly, we still have many issues to resolve but as we collectively develop a truly global Internet of Things in future.

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