Challenges in the Design of an IoT Testbed

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abstract:
Testbeds are pivotal at different stages of building of a product.Testbeds for academic, in any case, have distinctive prerequisites as compared to the testbeds for industry. Testbeds for academic utilization got to be adaptable sufficient to back heterogeneous sensors, heterogeneous conventions and adjustment of conventions, whereas keeping up a controlled and repeatable environment for the experiments. In this paper, the creators examine the challenges within the improvement of an IoT based savvy building testbed for academic. The plan of a adaptable testbed that bolsters inquire about and improvement of different plan components, specifically organize communication conventions, application utilize cases, cognition and security, of a savvy building is presented. The demonstration setup of this testbed for indoor environment checking, in conjunction with sample visualizatzions is additionally displayed.

1 Introduction

As you know, the Internet of things is important in our modern age because it facilitates our lives and makes them the simplest possible way by extending the scope of computing to the physical world and that mean is shift the environment of computing more to a distributed and decentralized form. also the implemented for IoT is complex and before we implemented the IoT we must make test and that is what we'll talk about in this paper testbeds, A testbed may be a stage for conducting rigorous, transparent, and replicable testing of logical theories, computational instruments, and unused innovations .Such testbeds can be used for the different stages of the engineering, that's , investigate, advancement and generation.The trending IoT industry has resulted in the development of testbeds which have been discussed in literature.The plan talked about in this paper is for a savvy building application utilizing multi-domain innovations. A four tier architecture supporting different utilize cases with heterogeneous sensors is utilized. The sending is for indoors with open air expansions, whereas the testbed is portable to include adaptability within the plan of tests. and as you know in the first paper we talked about IoT TaaS(internet of things-Testing as a service) and we will review here the problem in the first paper and the problem for this paper(but there is a different between the two papers because the firs talk about IoT Taas and this paper talk about testbed).

1.1 problem

1.1.1 problem (IoT-TaaS)

1. Conformance testing.
   (a) Architecture for Conformance testing.
   (b) Challenges for IoT Conformance testing.
2. Interoperability Testing.
   (a) Architecture for Interoperability Testing.
   (b) Challenges for IoT Interoperability Testing.
      i. Testing between remote IUT.
      ii. Testing between distributed IUT.
3. Discussions and challenges.
   (a) Testing coordination.
   (b) Testing costs.
   (c) Testing scalability.

1.1.2 problem(IoT Testbed):

The authors here are trying to solve the problem of applying this test in an internal environment that is observable and repeatable, and that this test may be used by academics and be flexible and they will seek to apply this test and we will see what are the challenges faced by the authors.

1.2 Related Work:

as a TaaS service which was in the past paper "IoT-TaaS: Towards a Prospective IoT Testing Framework" the testbed are enables to built with the 6 requirements:

1. Straightforward utilize interface devices to bolster arrangement, programming and logging functionalities.

2. simple enrollment handle for testbed benefit supplier for including their testbed to the arrange.
3. basic asset allotment handle for a client.
4. notoriety conspire for rating based on its execution within the experimentation.
5. motivation system for budget estimation for a specific test.
6. security approach to ensure assets from malevolent exercises. [1, 2]

1.3 Challenge:

the requirements of an academic IoT testbed. any testbed needs to support:

1. large volume of data
2. large number of devices
3. heterogeneous sensors an academic IoT testbed needs to in addition support
4. heterogeneous network and communication protocol
5. open source software and firmware
6. multi-purpose.

that is support for multiple use cases. and these six requirements provide for scalability, flexibility, controllability and repeatability of experiments. translating these requirements into a design is a challenging task when the resources time, human and funds are constrained.

testbeds has many challenges and these challenges are discussed from three different perspectives which is:

- **Resource Challenge:**
  The project duration: this challenge is about project duration in general may takes a couple of years. That is, it extends a few semesters.
  students tenure: is in terms of semesters and available only part time because for their other courses. Only PhD students are available for longer durations, but then their research problem should be in the same domain.
  Limited funding: in academic project funds are limited, especially toward human resources, comparing to the industry projects.

- **Technical Specification:** Technical challenges are because of the open ended specifications. The scope of the testbed for an academic IoT testbed could be encompassing one or more of the following.

  1. protocol performance testing and improvements.[3, 4, 5]
  2. Algorithm research.
  3. framework feasibility study.
  4. interoperability testing.[6]
  5. use case development with analytics.

  Lack of definition of use cases: Academic testbeds are created for varied use cases. in smart smart buildings can have multiple use cases like smart Heating Ventilation and Air Conditioning (HVAC), etc...
  Lack of definition of communication and networking protocol: industry testbed would require testing a specific application using a particular set of protocol and the usage scenario and the communication and networking protocols are predefined for it.
  Lack of specification of sensors and actuators: he sensors and actuators are use case dependent. For example, energy conservation would require wireless operated switches, lights, energy meter readers, AC controls, environmental sensors etc...

- **Technical Design:** The design of an IoT testbed for academics for the requirements projected poses several design challenges.
  the choice of embedded platforms and OS: The embedded systems need to be well documented and need to be "white boxes"' with open operating systems.Usage of open source platforms ensures flexibility of adding/removing sensors, modification of protocols, switching over between protocols and adding proprietary processing algorithms. and the algorithms encompass cryptographic, error protection, compression or cognition functionalities.
  Choice of data storage, search and visualization tools: the choice here should be based on them being open sourced which has direct impact on the support available, flexibility, to modify and cost factor. the development language needs to be widely used ones like Java, Python or c++.

interface to Analytics: here in the final challenge provides interfaces to different application for analytics. the open source analytical tools and also legacy analysis software need to be supported.

2 Methodology:

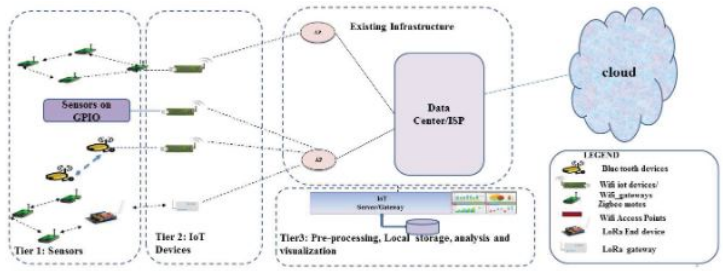

Figure 1

Methodology: the testbed design discussed is for a smart building using IoT technology. smart building encompass smartness in different aspects like parking, irrigation, lighting, security access control (Face recognition, access RFID cards), security intrusions detections and HVAC and disaster management, and it could be fire or flooding within the building. The control decisions are made by the application which sends command to HVAC units, lighting system, security alarms, and other actuators though the IoT devices. Fulfilling the objectives of a smart building testbed requires architectural tiers, namely, sensors and actuators as tier 1, IoT devices as tier 2, local real time analytics and storage at tier 3, and cloud based application as tier 4. **Figure 1.**

1. **Heterogeneous Sensors:** In order to observe the environment, sensors to measure temperature, light intensity, gas, humidity, pressure and to detect sound are spatially distributed across the observation area. The sensors have been integrated on a house developed environmental sensor card shown in **Figure 2.**

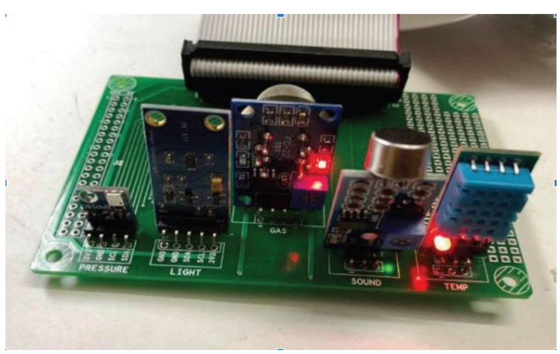

Figure 2

2. **Heterogeneous networking and communication protocols:** Each of the sensors has an interface for communicating with the IoT device. The communication protocols used are Wifi, Bluetooth, Zigbee and LoRa. The IoT devices send data to the IoT server periodically.

3. **Embedded hardware and software for IoT devices:** The IoT devices are based on Raspberry Pi3. The OS on the Raspberry Pis chosen is Ubuntumate. The client software running on each of the IoT devices is written as a python script. The period is configurable in the code. The IoT server is designed using Elasticsearch Logstash Kibana (ELK or Elastic Stack) [7].

4. **Preprocessing, storage and visualization software stack:** The major advantage of using ELK stack is it being open sourced. It is also easy to use and has now become very popular and powerful tool for data storage and visualization. The installation of Elasticsearch, Kibana and Logstash is as per the procedures shown in [7]. Say each JSON document is approximately β kb. Let η be the number of IoT devices. Let the polling rate of the sensors to provide the data to the server be ρ times/hour. Then the number of JSON documents d generated per day is given by eq. $d = \rho * 24$ The memory M consumed in the server memory per day is then given by eq $M = d\eta\beta \quad$ kb

   For a typical β of 15kb, 10 IoT devices and a polling rate of 30 minutes, the memory occupied in the server is 7.5 Mb approx. Dell Power edge T30 Mini Tower Server Desktop, Intel Xeon E3-1225 V5 3.3G, 8M Cache, 8GB UDIMM, 2400Mt/S, 1TB Hard Drive the server used in this testbed.

5. **Analytics interface:** The analytics platforms considered were Matlab, R and Python. The interface to read from the elastic search storage into these analytics platform was included in the design **(refer Figure 3).**

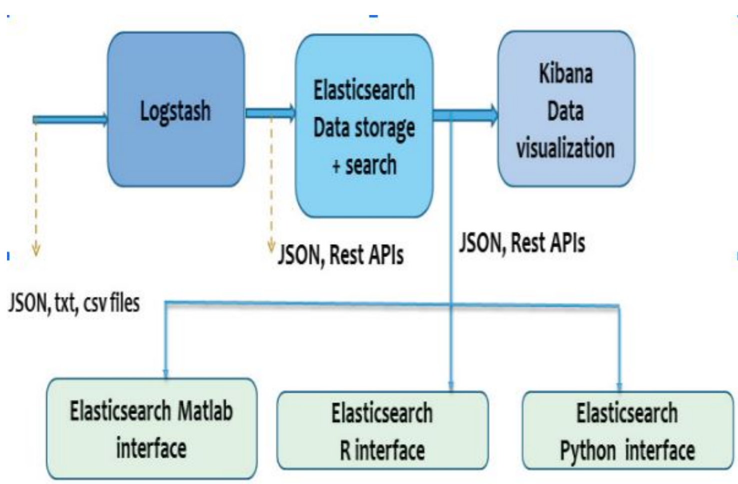

Figure 3

3 Results:

The explore setup is for environment parameter checking of a room. The natural sensor cards with IoT tools are dispersed over the room, in numerous zones. The IoT tools collect the parameters specifically, mugginess, temperature, weight, gas level and light escalated.The concentrated of lights is distinctive over zones as well as shifts with the time of day. This data can be utilized as input to bulbs whose escalated can be controlled and the sum of increment or diminish of the light concentrated . Additionally, the AC vents setting control depends on the temperature distinction between open air and indoor temperature estimations.The concentrated of lights is particular over zones as well as shifts with the time of day. This information can be utilized as input to bulbs whose raised can be controlled and the whole of increase or lessen of the light concentrated . Moreover, the AC vents setting control depends on the temperature qualification between open discuss and indoor temperature estimations.

4 Conclusion:

The challenges within the advancement of a savvy building testbed for academic have been talked about in profundity. The design of a adaptable testbed that bolsters investigate and development of a smart building has been presented. Different explore can be outlined, sensors can be added, protocols can be changed, included or exchanged, cognition at IoT tools level or organize level can be included. Security authentication conventions and encryption calculations can be added depending on the arrangement. This is often conceivable since of the engineering and components chosen. Outdoor extensions are possible by using outdoor sensors. Mobility extensions are being planned with robots. The tier 4, the cloud deployment for applications with analytics can be easily achieved by using the cloud version of elasticsearch. In this case the IoT server would act as a gateway and the analytics, cognition and other cloud services can be utilized.
There is not any compare between the two papers we worked on, but the main point among them is both of them are under the "Internet of Things" but each paper took a branch of it with specification, For example in this paper it took it in real life using something like smart home.
may help graduate project ?
In the end this paper would help students in a graduate project, it built for students in specific for testing and creates something new like a robot by using hardware and testbed. The limitation of this use is a university's budgets, may some university have not enough budget for a graduation's project.

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