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An Innovative Cloud Framework for Tracking and Monitoring Tangible Assets in a Smarter Campus Using RFID

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Abstract: In a technological world, every entity both natural and man-made areto be imagined as memory based objects in which information can be stored and queried later. Tracking, monitoring the location, environment status of these objects has been the basis for many real time applications to make fine grained decisions to improve the operational performance. Universities and academic institutions have campuses facilitated by many fixed assets. Adding more complexity to this is the management of the assets, so far it's a labour intensive, time consuming, lack of immediate response problem. We propose a framework, providing smart computing features, to overcome the everlasting worries pertaining in the managerial bodies concerned about their valuable assets in the campus. The proposed framework extracts the benefits from the RFID and cloud computing technologies, to ease and improve the work efficiency of the administrators, librarians and other responsible departments members to ensure that there is no misplacement and missing of assets that are massive in numbers. The framework enables automatic caching, filtering and processing of RFID events (using Hadoop) that are generated in a smarter campus. Proposed framework is implemented at department level and the results we got proved its feasibility for implementing in smarter campus.

Key words: RFID, asset management, university campus, hadoop, cloud computing bigdata

INTRODUCTION

Now a days, desire of people is to choose a smart car, a smart pen, smart business, smart campus amidst their ordinary counterparts. Thus smartness has been a wish in almost all the fields (Mayer and Guinard, 2011). Further, today people are interested in publishing their life moments on-line and are curious enough to know about day to day happeningsof their loved ones. But the pathetic situation indeed is that they are struggling hard to find out goods that they themselves own. We believe that in near future people would be happy, if they could use a webpage to track their t-shirts and pants (whether they are with laundry, or to be included for it, or is readily available at some defined location in the shelves). We also believe that people will be even more satisfied if the apparel, when wore, could intimate them that it belongs to his brother and not his own asset. This thinking is not a metaphor, a vision or a proposal it is a rapidly emerging reality with theadvent of Internet-of-Things (Gupta *et al*., 2011). Dominique Guinard, who was super motivated byinternet-of-things has researched and introduced a mug that could alert a coffee drinker, when a programmed temperature of the drink, has reached. He further equipped the mug such that his colleagues can also be notified with message that this particular person is having a coffee break and they can join him if needed (Guinard *et al*., 2011).

Education is a field in which the key role players of next generation are beingequipped and empowered. In contrast, these universities have massive number offixed tangible assets right from chairs, tables, projectors, room heaters, air conditioners, sound systems, library books and lab equipment that are scattered overwide spread areas. These assets will look alike when they are of similar categories. The research of the employees has always been on vain and time consuming in making sure that both similar and dissimilar assets can be located perfectly inplace for use when needed. Their wish and expectation is to experience, a soothing solution to the everlasting, tedious and mind breaking problems they had in monitoring them.

Literature review: Radio Frequency Identification (RFID), is not a new technology and is used inmilitary, airline, library, security, healthcare, sports, animal farms and other

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areas. The advancement in RFID technology (Sarma, 2004; Floerkemeier and Sarma, 2008) has brought advantages in the areas of resource optimization, enhanced customer care and increased efficiency withinbusiness processes. Smartness has been a wish in almost all the fields. To creates marter planet, every entity both natural and man-made are to be instrumented and interconnected (Engels *et al*., 2001). What is believed in near future is that people may usesmarter things, to track their belongings such as t-shirts, pants, shoe laces andmany more. We have listed some of the applications (Domdouzis *et al*., 2007) where RFID is used. RFID is used in as set tracking (Oztekin *et al*., 2010) to find exact location:

- For proper placemen tof newly procured assets
- The assets to service them periodically
- Assets if their rental period is over
- To maintain updated and accurate details about the assets prevailing within organizations
- To reduce time and cost spent in searching missing assets

RFID is used in healthcare to protect important resources, save patients waiting time for every sequential, procedural, check-up process. RFID applications contributes widely towards the uplift of patient care. RFID is used by hospital staff's:

- To track medical equipment in a timely manner
- Used in soap dispensers, confirms that nurses have washed their hands properly
- To track patients, so as to reduce the spread of contagious diseases and also to record their medication details

This increases efficiency and effectiveness of paramedical staff which further results in improved patients experience (Ahsan *et al*., 2009, 2010a; Meiller and Bureau, 2009).

RFID tags can be attached to the equipment or user's organization ID card sand their vehicles. By using RFID application (Lo and Yeh, 2007) in secure zones the permission can be granted and revoked for users or persons in particular zone. Also, it can be used to record important data such as individual access and the length of their stay. This mitigates time spent in audit trial.

RFID (Ahsan *et al*., 2010b; Xiao *et al*., 2007) is also used for auditing and controlling security persons themselves. During the sequential patrol of security guards, data is recorded in the RFID equipped check point. This not only help security firms administration to check the performance of its security guards but also used as a reference to track events during forensics examinations. This application also helps in improvising the patrolling process in deciding the need to increase patrols or check points ina patrolled area.

Airline, package and delivery services undergo a very liable monitory loss due to late delivery of baggage and packages. Handling large amount of delivery to various destinations on different routes can be very complex. In this scenario, RFID application (Vijayaraman and Osyk, 2006) provides best resource management, effective operation and efficient transfer of packages. RFID helps in tracking the movement of the baggage. This provision helps customers to be informed about their baggage in advance. Further, such provided data records assist the industry in pinpointing possible areas that may require some improvements.

RFID-enabled services are increasingly used in supply chain management (Sarma, 2004; Michael and McCathie, 2005) by fixing RFID tags on the pallets or products and using special readers to track the products. If a retailer who sources his products from several locations and has operations in different cities wants to have real-time data of the goods in his ware houses and at the outlets, he can go in for the RFID enabled services. For example, Dubai-based hexomatrixx has taken the technology forward by integrating the RFID reader to smart phones. It has already tested and there are plans to launch it soon. Some of the large businesses are already using RFID technology, apart from bar coding. The potential is huge in supply chain management and logistics, especially in the manufacturing, life sciences and retail segments for asset tracking, ensuring security of the products, increasing productivity and removing operational hitches. In a modern logistics facility, every process within the ware house and distribution centre can be tracked to the pallet. The pallets are tagged with RFID. When it is ready to be moved, it is picked up on a for klift that has an RFID antenna.

RFID applications have exalted the toll collection (Xu, 2008) by surpassing previously used operation strategies. By automatically identifying the account holder, it notonly improves traffic flow but also aids in obstructing vehicles passing through toll stations when there is a denial in necessary payments. The application of RFID also succours administration and decision support systems in identifying traffic patterns using data mining techniques. Such reports are then used for planning future policies.

From the earlier studies, the importance of RFID can be noted, we planned to adopt this technology for managing the tangible assets in universities. Manual process of managing assets is a tedious job which may take many hours and days.

In this study we have proposed our idea (and implemented) to improve the process and to find out the missing and misplaced assets. The proposed framework is implemented:

- To overcome the problem of administrators by helping them to ensure that all the assets such as equipment's and furniture's are in place and are not missing
- To alert the administrators regarding the identified discrepancy among the traceable assets (providing visibility about the movement of assets as opposed their allowed locations)
- To locate the assets when they are required collectively for any upcoming happenings (such as workshop, seminars, international conferences) in the campus
- To generate reports for auditing in few minutes which previously took many man hours
- To replace the obsolete models
- To return rented assets on time thereby to get rid of overdue charges incurred

MATERIALS AND METHODS

Proposed framework: The proposed framework is applicable to any tangible asset. The desired outcome of the proposed research is to empower university administrators in their main tenance work and increase the integrity of asset location details maintained by them. The architecture of the framework portrayed is shown in Fig. 1. The framework has four main parts namely User Interface, EPCIS (Electronic Product Code Information Services) server, EPCIS Repository, RFID System enabled rooms (this includes RFID reader, RFID tag, RFID middleware).

The proposed application is developed by combining the feature of RFID and Cloud Computing. As the assets in the department grow, tracking the assets is not an easy job. To find total number of assets, misplaced and lost assets, we use RFID tags to check the present position of the asset. The proposed framework comprises of:

- Web interface
- Product Mark-up (PML) which acts as a masterrecord for all assets in the college campus and stored in cloud storage
- Designand implementation of EPCIS service
- Generation of event logs
- Authenticated report generation

User Interface (UI): The proposed research embraces, an attractive high usability featured user interface, accessible through a web portal. The user interface components allow the authenticated officials to:

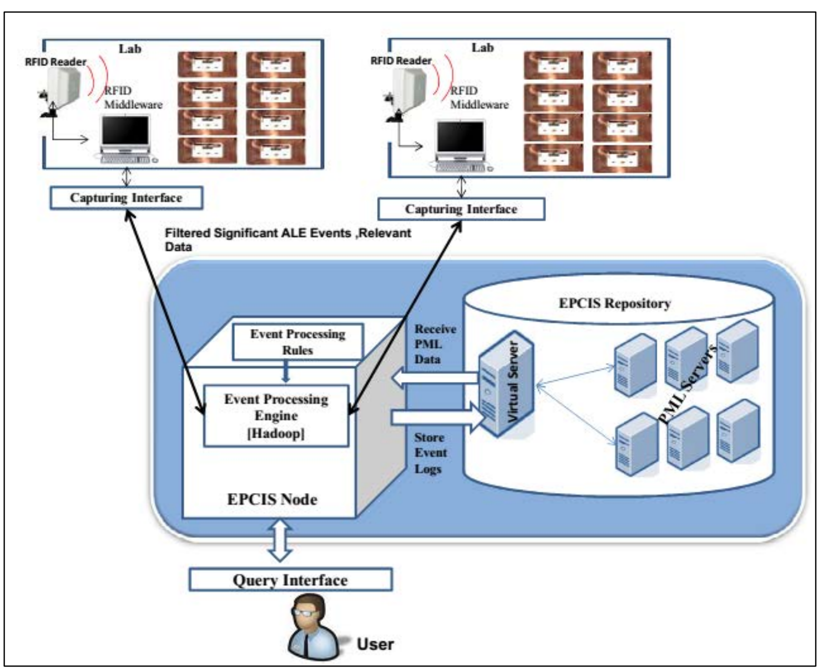

Fig. 1: Framework proposed for smart campus university

- Enter the details of newly procured assets and also to perform constrained CRUD (Create, Read, Update and Delete) operations, if necessary to the available master details of the existing assets
- Generate reports for auditing and inspection purposes
- View room based equipment status tables to re-solve the problem of missing and misplacement of assets by identifying the correct location which previously took months

EPCIS server: EPCIS is the bridge between the physical world and information systems. In our proposed work we incorporate EPCIS to facilitate authorized university officials to view relevant context information, thereby track and trace their valuable assets anywhere if connected. This expedites them towards ensuring the presence orabsence of assets in the campuses. In our proposed work EPCIS node, is the host department server. This provides a gateway service point which exposes filtered, significant application level log events prevailing in the department to the authenticated administrative users. As stated before, EPCIS server uses two interfaces:

- Query interface, a query submitted to EPCIS Server
- Capture interface, EPCIS communicates with RFID reader to collect files containing captured tag id's only

EPCIS server performs the major processing involved in the application. It collects three files from RFID readers in lab rooms namely:

- Complete assets (containing entire assets read in respective rooms)
- Missing assets
- Misplaced assets

EPCIS repository: Repository is a storage part this repository will maintain PML document which is shown in Fig. 2. Physical Mark-up Language (PML) was conceived for describing physical objects using standardized vocabularies. The details maintained in the repository includes:

- Master asset details stored as PML data these details are added into the repository using user interface by authenticated officials
- Logs stored using PML data, this comprises details of events captured and are maintained for 6 months in the repository

Lab server machine compares the collected data counts with asset count for each lab from Department Server, Send Alert Notifications (E-mail) to officials, generate complete status report for every individual lab, transfer the complete asset status files to department lab servers.

Figure 2 enables in understanding the PML based master details of an asset. In this framework RFID reader is used for capturing EPC values from RFID tagged equipment. PML is the data model used for encoding both the master asset details and logging events (i.e., data captured and stored for audits and discrepancy conclusion purposes).

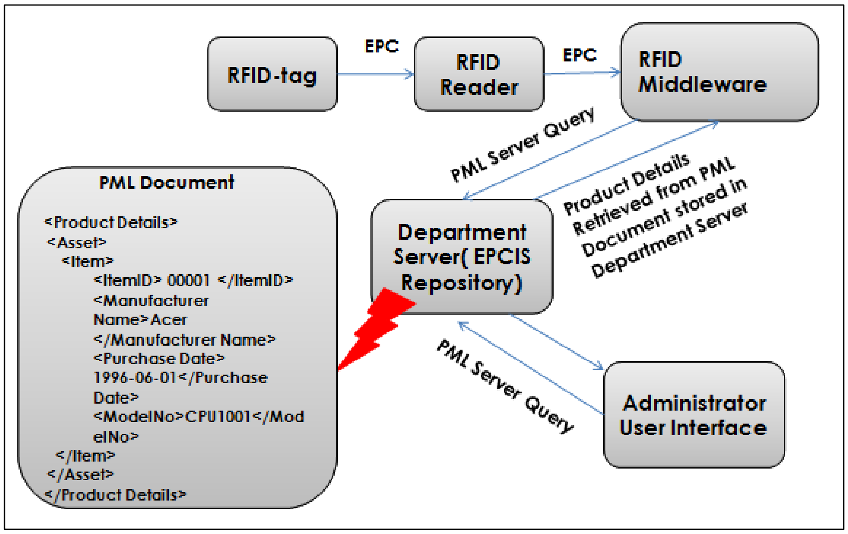

Fig. 2: Framework comprising of EPCIS global network components event

The functional and non-functional benefits of the proposed framework are listed. Functional benefits are:

- If any asset is missing in its location, it is now possible to find out where the asset got misplaced and if not misplaced, whether it is being theft
- The asset status is logged continuously in the system and can beutilized to generate reports even over a long period of time
- The presence of any such discrepancies, are automatically notified to officials through E-mail and SMS alerts
- As authorization is verified, during the time of login and the system filters query based events and present only relevant details
- Internet capable mobile devices can also be used check the assets on-the-go. This makes the officials to exercise their duty beyond campus borders

Non-functional benefits are:

- Supports reduction of global warming and save senergy for future generation
- Makes the university campus smarter
- Utilizes the existing infrastructure to provide smartness
- Helps in making right decisions at right time by real time data acquisition
- Enables easy and reliable asset tracking service over anything, anywhere, anytime

Work flow: The design of the framework can further be explained with the work-flow as portrayed in Fig. 3. In each lab, a system acts as a server for that lab and a system in a department office act as a server for the entire department comprising of many labs. This implies that department server connects with all the lab servers. As shown in the Fig. 3, initially the middle ware instructs the RFID reader to capture the EPC value of the tagged assets. The lab server module queries for the count of the type of asset in each lab. This value is fetched from the department server. This data is used in identifying the movement of asset. Thus, the misplacement of the asset is now visible and identifiable. Whenever, such a kind of discrepancy occurs, an alert notification is raised and intimated to the administrators duly via E-mail and also as a message. The complete EPC file, received by the lab server is sent to the department server. The department server (EPCIS node) processes the files to identify which asset is moved to which lab. The generated events are logged into the EPCIS repository. The administrator can then log on to any internet connected systems to view the entire status and if necessary can generate complete reports. The expected information from the framework is portrayed in the Fig. 4 as table, in which the monitor was identified to be misplaced in the lab named PGLab1, Fig. 5 portrays the snapshot of assets based on time, here it is taken at 8.00AM in PGLab1.

Experimental setup: The problem pertaining in the university is that there are large number of building blocks

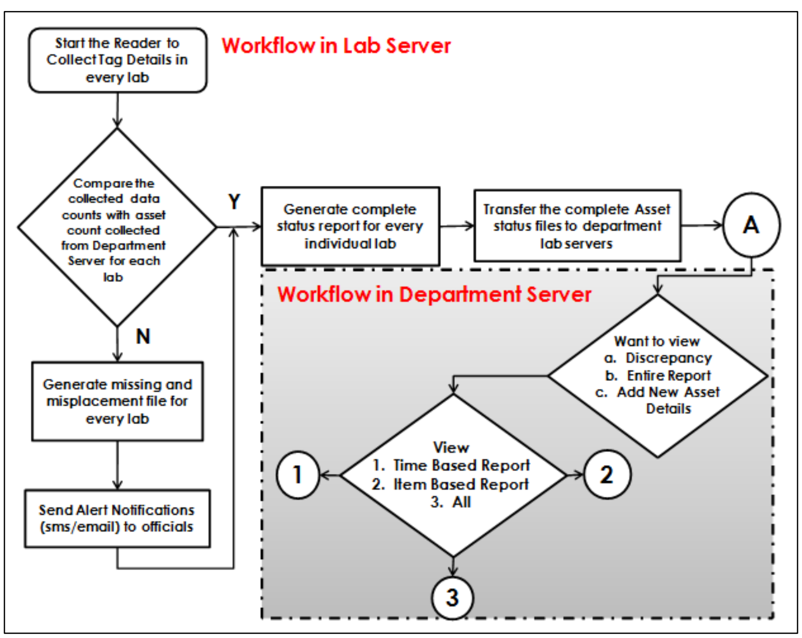

Fig. 3: Overall work flow

Name	ID	Tag ID	Item	Time	Status	Time	Status		Time	Status	Date
Lab 1	PGLab1	123255	CPU	8:00	Ok	9:00	Ok	...	3:00	Ok	12/08
Lab 1	PGLab1	123251	CPU	8:00	ok	9:00	ok	...	3:00	ok	12/08
Lab 1	PGLab1	234596	Monitor	8:00	misplaced	9:00	misplaced	...	3:00	misplaced	12/08
Lab 1	PGLab1	567455	Keyboard	8:00	Ok	9:00	Ok	...	3:00	Ok	12/08

Fig. 4: Snapshot for entire view of assets in PGLab1

Name	ID	Tag ID	Item Name	Date	Status
Lab 1	PGLab01	123255	CPU	12/08/11	Ok
Lab 1	PGLab01	123251	CPU	12/08/11	ok
Lab 1	PGLab01	123256	CPU	12/08/11	Ok
Lab 1	PGLab01	123257	CPU	12/08/11	ok
Lab 1	PGLab01	234596	Monitor	12/08/11	misplaced
Lab 1	PGLab01	234597	Monitor	12/08/11	ok
Lab 1	PGLab01	567446	Keyboard	12/08/11	ok

Fig. 5: Snapshot for time based view of assets in PGLab1 at 8:00 am

across wide spread campus that is sprawling in acres. Each building blockin turn has large number of rooms and each room in turn, have large number offixed tangible assets. For a university, our proposed framework could track the equipment and resources. On experimental basis, the proposed framework was setto track five basic assets in department computer labs namely the CPU, monitor, keyboard, mouse and chair, respectively.

In our research we used the EP500 fixed RFID reader. The chosen reader is capable to read/write the tag which complies with ISO-18000-6B standard and EPC CLASS1 G2 standard. This reader is widely applied to data collection systems, such as vehicle access control, ETC, personnel access control, electronic anti-counterfeiting, logistics control, auto-production. In our proposed framework, the user collects three files from readers in labrooms namely:

- Complete assets
- Missing assets
- Misplaced asset files

And also, details are collected in timely manner i.e., for every hour the assets detailsare collected and stored in a local lab server. In the end of day, it will be stored for backlog processing. A university will contain many departments and in turn department will have many labs with many assets. For example, consider computer science and engineering department consistingof many labs (Fig. 6):

- CSE department has 10 Labs: A lab is equipped with 40 Systems consistingof CPU + Monitor + Mouse + Keyboard + Chair
- Totally 40×5 = 200 Assets
- Each asset will have tag of size 512KB (Containing details such as asset Id, labname etc.)
- 200 Assets x 512 KB = 100 MB
- 100 MB x 8 h of transaction data = 800 MB
- 10 labs x 800 MB = ~8 GB day^{-1}

Likewise, consider a library containing books in shelf (Fig. 7).

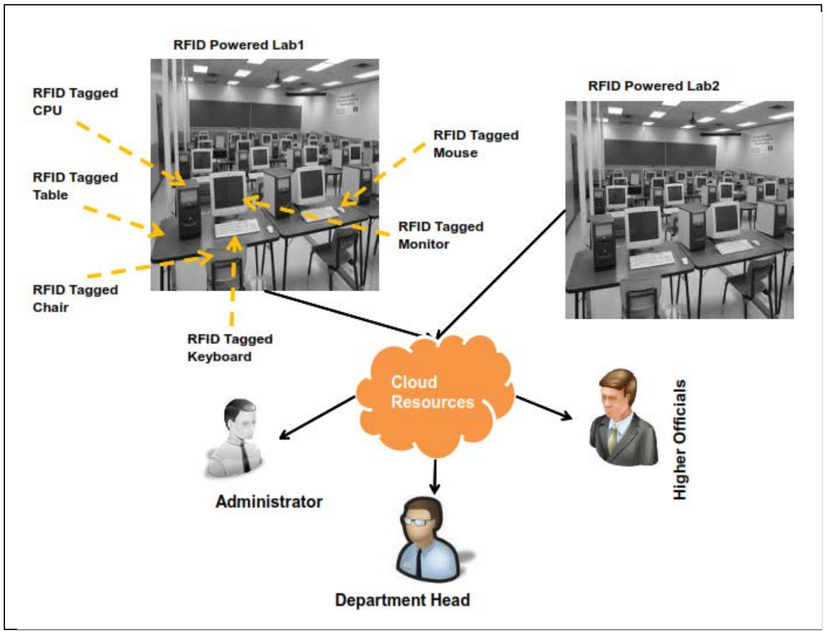

Fig. 6: Scenario in computer lab

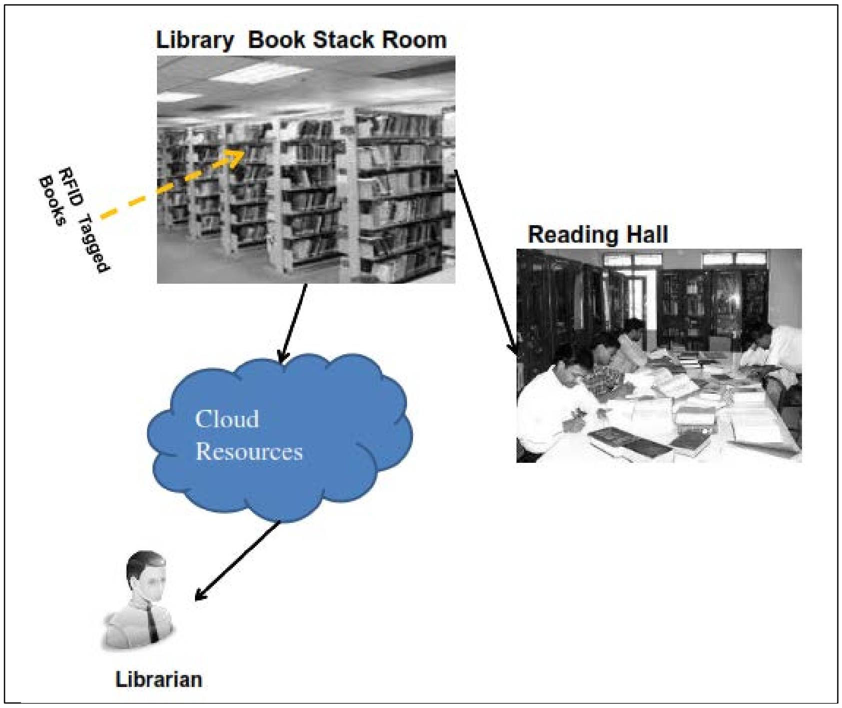

Fig. 7: Scenario in library

- CSE department library has 20 racks: A racks holds 100 books
- Totally 20×100 = 2000 assets
- Each asset will have tag of size 512 KB (Containing details such as asset Id, book name, acc. no etc.)
- 2000 Books x 512 KB = 1000 MB
- 1000 MB x 8 h of transaction data = 8000 MB
- ~8 GB day^{-1}

We can similarly expect the generation of less than or more than 8 GB data every day as university campuses do comprise many departments. With the development of

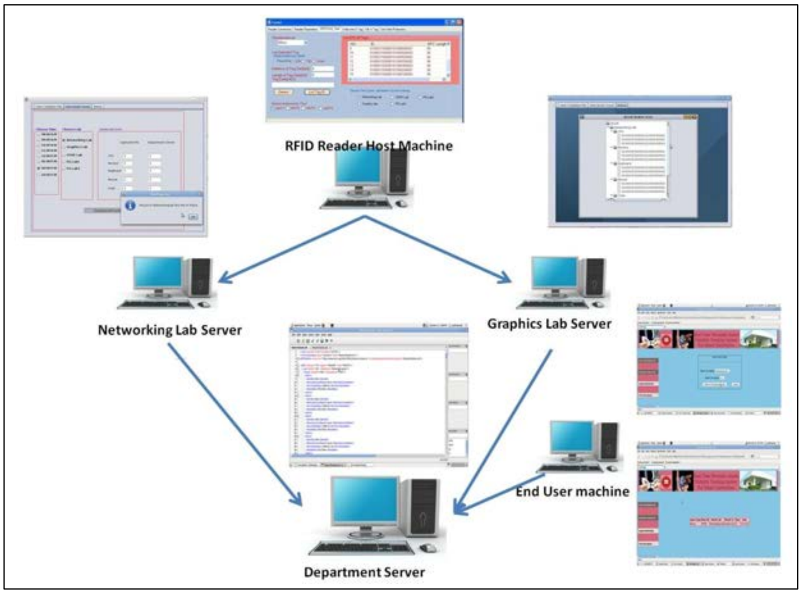

Fig. 8: Machine screenshots

cloud computing, the Distributed File Systems (DFS) are getting more and more attention. Client-Server architecture is the basis for DFS. In a DFS, one or more central servers store files that can be accessed with proper authorization rights by any number of remote clients in the network. Thus, retrieved remote file appears as a local file on the client machine. One among such type is HDFS which has several strengths such as:

- Write-once-read-many (worm) access model
- Usage of commodity hardware with relatively less failures rates
- Provision for streaming long, sequential data accesses
- Support for large data sets
- Hardware/OS agnostic backup
- Strategy of moving computation than moving data

We choose HDFS as a solution to overcome the problem of contiguously accumulated data in the usage of RFID system in universities and used Hadoop to process the generated event logs. The proposed framework is implemented using the RFID system hardware and Hadoop cloud.

Figure 8 specifies the machine used and the corresponding snaps hot of the proposed framework using RFID technology and web services.

- Machine 1 (top middle): RFID reader host machine, the machine connected to reader that is fixed in the lab
- Machine 2 (second row left): Networking Lab Server, the main machine in Networking Lab Receiving the captured file from reader
- Machine 3 (second row right): Graphics Lab Server, the main machine in Graphics Lab Receiving the captured file from reader
- Machine 4 (down middle): Department Server, the machine for entire department receiving the captured files from lab servers
- Machine 5 (down right): End User Machine, the machine the administrator uses, to view entire status of assets in all labs using browser

RESULTS AND DISCUSSION

For the proposed work the data collected are processed using Hadoop HDFS. Our experimental set-up contained three different node configurations as:

- Intel i5 with 8 GB RAM (Type A)
- Intel i3 with 4 GB RAM (Type B)
- Intel Pentium Core2Duo with 2 GB RAM (Type C)

As a first step in using Hadoop environment, jobs were written using the map reduce programming model using Eclipse IDE. The client, also a slave in the cluster configured, submitted the job and the necessary data were retrieved from the department server node. Following queries are a glimpse about the jobs submitted to the Hadoop cluster:

Table 1: Comparison of time consumed (hadoop after modifying cluster configurations)

Nodes	Master	Slave 1	Slave 2	Slave 3	Time taken
IP	10.6.2.1	10.6.2.2	10.6.2.3	NA	9 min 25 sec
CPU	Type B	Type C	Type C	NA	
IP	10.6.2.1	NA	10.6.2.3	NA	10 min 42 sec
CPU	Type A	NA	Type B	NA	
IP	10.6.2.1	10.6.2.2	10.6.2.3	10.6.2.4	9 min 57 sec
CPU	Type A	Type B	Type C	Type C	
IP	10.6.2.4	10.6.2.2	NA	10.6.2.1	8 min 24 sec
CPU	Type A	Type B	NA	Type C	
IP	10.6.2.4	NA	NA	10.6.2.4	8 min 48 sec
CPU	Type A	NA	NA	Type C	

Table 2: Comparison of time consumed (Hadoop after modifying block size and Maps)

Block size No.	No. of Maps	Time consumed
64MB	180	8 min 56 sec
128MB	100	4 min 21 sec
256MB	60	4 min 17 sec
512MB	20	4 min 32 sec

Table 3: Experimental results

File size (GB)	Java	Hadoop	Hadoop (Clusters)	Hadoop (Block size)
8	5.59	8.31	8.24	4.17
10	7.38	10.38	10.30	5.21
25	17.46	26.36	26.15	13.03
50	35.33	52.33	51.50	26.06
100	70.27	104.27	103.00	52.13

- How many CPU, monitors, keyboard, mouse, chair are in the Networking Lab?
- What is the LabID of Graphics Lab?
- What are the details of Monitors in Graphics Lab belonging to Manufacturer ACER?
- What are the Monitors in Graphics Lab purchased between 1-1-1995 to 1-6-2015

The results when compared with the plain, simple Java program, it was observed that the time taken for normal Java program was 5 min and 59 sec.

Unfortunately for the same input, when job was executed using Hadoop Map Reduce programming model under a cluster of 4 nodes with one node as Name nodeand 3 other nodes as Data nodes, took 8 min and 31 sec. To further reduce the time consumption in the execution of jobs and to improve performance, the cluster was altered with various combination of commodity hardware and for each configuration, the time consumed for the job is observed. The list of cluster combinations can be viewed in the Table 1.

After changing the cluster nodes, the block size was observed to be the victim for no improvements in performance. The block sizes were changed as 64, 128, 256 and 512, respectively. From the Table 2, we can infer that, the optimum block size for, the considered map reduce job for 10 GB input file size is 128 MB. This added towards performance growth. In benchmark 64 MB block size

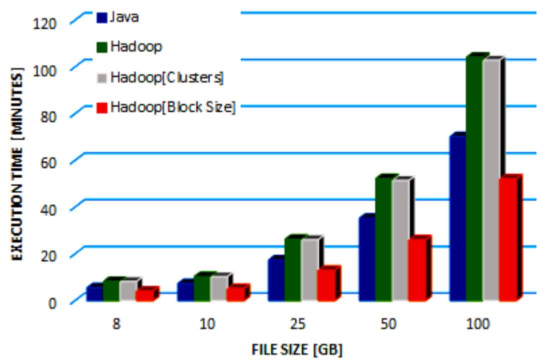

Fig. 9: Overall comparison

against 128 MB block size, a reduction in time from 8-4 min was observed. Table 3 presents the results got for different sized data and are processed using:

- Standalone Java program
- Hadoop
- After changing clusters (Hadoop)
- After changing block size (Hadoop)

From the Table 3 and its graph (Fig. 9), it can be noticed that block size and cluster configuration plays a vital role in improving performance.

CONCLUSION

The application of RFID and Hadoop to the universities may become a start for the university peoples to improve and administrate effciently to track their valuable equipment. This eliminates the manual work hours involved in performing time consuming audits. This proposed framework improves the responsibility of the administrators by facilitating them with E-mail alert notifications. Initially, the proposed framework is implemented only for the department of computer science and engineering. RFID technology records huge, unmanageable data, to manage these data cloud computing technology is used. We also adopted and performed some tuning in the Hadoop cluster environment to achieve optimal performance. From the results we got, we found that for a file of size greater than 100 GB, keeping the block size of 128 MB does not improve performance. We also suggest that for files >1 TB size, increasing the block size as 256 and 512 MB will be meaningful in terms of performance. We created a framework and testedit in smaller section, this will be applied to all the departments in the university which is our future work.

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