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| Grifo UA preto | **University of Aveiro**  **2015.** | Department of Electronics, Telecommunications and Informatics | |
| Vedran  Semenski | SMARTIE – Secure and Smarter Cities Data Management | | |
|  | Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em (designação do Mestrado), realizada sob a orientação científica do Doutor (nome do orientador), Professor (categoria do orientador) do Departamento de (designação do departamento) da Universidade de Aveiro | | |
|  | texto Apoio financeiro do  (se aplicável) | |  |

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|  | texto Dedico este trabalho à minha esposa e filho pelo incansável apoio.  (opcional) |

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| o júri |  |
| presidente | Prof. Doutor João Antunes da Silva  professor associado da Faculdade de Engenharia da Universidade do Porto |
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# List of Acronyms

|  |  |
| --- | --- |
| ABAC | Attribute-Based Access Control |
| ACL | Access Control List |
| CC | Portuguese Citizen Card |
| CLI | Call Level Interfaces |
| DAC | Discretionary Access Control |
| DACA | Dynamic Access Control Architecture |
| DBMS | Database Management System |
| EKE | Encrypted Key Exchange |
| HDFS | Hadoop Distributed File System |
| IDAC | Direct Access Mode Interface |
| IDE | Integrated Development Environment |
| IIAM | Indirect Access Mode Interface |
| IoT | Internet of Things |
| JDBC | Java Database Connectivity |
| JVM | Java Virtual Machine |
| LDS | Local Data Set |
| LINQ | Language Integrated Query |
| M2m | Machine to machine |
| MAC | Mandatory Access Control / Message Authentication Code |
| NoSQL | Not Only SQL |
| OCSP | Online Certificate Status Protocol |
| PDP | Policy Decision Point |
| PEP | Policy Enforcement Point |
| PSK | Pre-Shared Key |
| RBAC | Role Based Access Control |
| RDBMS | Relational Database Management System |
| SAAM | Secondary and Approximate Authorization Model |
| SDP | Secondary Decision Point |
| S-DRACA | Secure, Dynamic and Distributed Role-based Access Control Architecture |
| SPEKE | Simple Password Exponential Key Exchange |
| SQL | Structured Query Language |
| SRP | Secure Remote Password |
| SSL | Secure Sockets Layer |
| TFA | Two Factor Authentication |
| TLS | Transport Layer Security |

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# Introduction

TODO: making the introduction and describing how the document is organized into parts with brief descriptions of each part

## Brief description

TODO: description of the thesis

## Defining the goal/concept

TODO: defining which part was determined as most important and which goals were set

## Basic concept

TODO: describing the basic concept of the solution (very briefly)

# State of the art

TODO: In this sections the madadnan will be explained and ...

TODO: This section is organized in this and this way...

## The Internet of Things (IoT)

In this section the current state of IoT will be presented. The main areas that will be briefly presented and analyzed are: current state and overview, general concerns, recent work and studies, technologies used, implementation examples and expected future developments.

The IoT is a recent paradigm in the area of networks and communication that has had a lot of growth and new developments in recent years. Although there are a lot of definitions of the IoT and the somewhat changing and branching nature of the development trends in this area the basic and simplified idea of this concept is that nowadays everyday objects can be equipped with cheap microcontrollers, sensors, means of connecting to one another and the Internet. The devices can generally be divided into two categories: sensors and actuators, meaning that their purpose is to provide and share data or some kind of readings or to receive commands and react/complete actions accordingly. The overall implementation and use of this could be used in a number of applications including: home automation, industrial automation, medical aids, mobile health care, elderly assistance, intelligent energy management and smart grids, automotive, traffic management and many others [1] [2]. All of these offer beneficial and significant impact on almost all areas of everyday life and have potential for providing advancements in research areas unrelated to networking or computer science. The definition of IoT is not exact as the authors of [1] wrote. They explain that the two main views come from the name "Internet of Things". One vision views the concept from a network perspective concentrating on communication and connection problems while the other is oriented on the "Things" or object perspective concentrating on sensor technologies, new communication technologies like RFID and NFC ,and integration into other devices in a seamless and affordable way. A third view is also present which the authors defined as a "Semantic oriented vision" which is concentrated more on the use, implementation and processing of data.

A number of challenges are in the way of successfully building and utilizing the IoT. Scalability is one of the obvious challenges. Any kind of IoT application that requires a large number of devices commonly face problems with response time, memory, processing and energy constraints. Other challenges include security issues. The data being generated by sensor networks is huge and could over saturate the network, the data could be personal and as such has to be protected from unwanted access. Attacks by hackers, malicious software, viruses and other sources can also disturb the flow and integrity of data/information. As the authors of [3] [4] [5] describe in their work and stress the importance of security for a widely acceptable solution. In their work they describes the IoT divided into 3 or 4 layers and define security requirements for every layer providing the current state of technologies used in these areas. They stress the need for an uniformed and standardised open architecture and solution. Solutions for many of these problems are already conceptually known and are in some examples implemented but the lack of a open and standardized solution is certainly an issue that would proved to be beneficial if/when solved.

Technological advancements in various sensor modules and cheap and energy efficient microcontrollers along with recent communication technologies like RFID, NFC and network protocols are the main factors that enabled the fast development and spreading the IoT. Because of these advancements the concept became a reality and is gaining importance and more uses and applications. As the means of connection and communication are open and utilizes a number of older and newer technologies the networks and number of devices is fast growing and also brings up the problem of standardisation and implementation of standards in the purpose of uniformly solving known problems with for instance security, integrity and scalability.

A more future oriented view and analysis is provided by [6]. It describes a more human centric rather than thing centric future of the IoT. Devices being linked to people and monitoring their state and condition. Others are used for monitoring or controlling things in the environment but always in close relation to human needs and/or wants. It describes a need for IoT applications to provide better quality of service and seamless integration into areas of life. The more relevant and faster growing application domains are: Environmental Monitoring, Smart Retail, Smart Agriculture, Smart Energy and Power Grids and Smart Healthcare. The architecture proposed is separated into 5 layers stacked one on top another in this order:

1. Things - containing devices or elements that are data generators and/or consumers of information. The devices could range from small and unintelligent embedded systems to complex devices or virtual entities. The communication would be done different communication technologies and a wide variety of protocols.
2. Network - this layer contains functionality and means of managing a sensor network. Discovery of new devices, maintenance, scalability, universal abstractions of the Inputs and Outputs and general abstraction for the upper and lower layers and enabling plug-n-play like use using already known models like push/pull or publish/subscribe models and REST based protocols.
3. Data Management - it is defined as "Big-Little" Data Management referring to the data usually generated by sensor networks meaning that the data generated by for instance temperature sensors is small in individual reading size large considering a large number of sensors over a period of time. This layer is responsible for categorizing and aggregating data retrieved from the Network layer in order for it to be used and/or by the Analytics layer. Data generated by sensors is often slow changing so this fact should be taken advantage of for more efficient data storage.
4. Analytics - this layer mines/retrieves data from the Data Management layer and performs data processing and analysis depending on the type of data and end user of the result. Is provides the applications (which would be located on top) with useful data and information for subsequent use.

There a lot of commercial implementations of IoT on a smaller scale which are mainly focused on personal use in home energy consumption, health monitoring and environment monitoring applications. These solution usually utilize custom solutions along with custom hardware (regarding the sensor devices). Introducing standards that would be accepted and the creation of publicly available frameworks that utilize those standards would be very beneficial and would allow easier further developments. The lack of said standards and frameworks mean during initial developments of applications many of them face the same problems and implement a custom solution. This leads to incompatibility issues and stand in the way of a truly global IoT. The surveys and proposals given in [5] [3] give a good overview of the current situation in IoT and a give proposals for more uniformed future research and developments.

## Machine to Machine communication (M2M)

This section will provide a brief overview of the current state, issues and a future developments in M2M.

M2M, which means "Machine to machine" refers to the technologies used for communication between devices. It is a broad term that can sometimes be used for terms like "Machine to Mobile" and "Man to Machine" which mainly refer to the implementation in a more precise manner. It is also commonly regarded in the context of IoT because it is essential part if IoT. IoT concentrates more on a higher overview considering network problems and viewing object in a more general way, while M2M deals more with one-to-one communication between devices and the functioning of devices regarding one another, less regarding the overview from a network perspective . The motivation behind M2M comes as stated in mainly comes from two observations:

1. a networked machine is more valuable than an isolated one
2. when multiple machines are effectively interconnected, more autonomous and intelligent applications can be generated
3. smart and ubiquitous services can be enabled by machine-type devices intelligently communicating with other devices at anytime and anywhere

M2M systems are mainly used in the areas of personal health monitoring and smart homes/smart houses. M2M communication can be achieved with a number of technologies but the most significant and most promising ones are wireless technologies. In the main technologies that are mentioned and review are: Zigbee, Bluetooth, UWB, IEEE 802.15.6, WiFi, HomeRF, 60GHz transmission and Visible light communications. They offer easy integration of devices and many options for developing application. Applications utilizing M2M systems are usually focused on improving the quality of life for individuals. The two areas that are most significant and are the main drivers for developments in M2M are "personal health monitoring" and "smart home" applications. Trends in M2M as mentioned in suggest exponential growth in the number of M2M-enabled devices. From 50 million in 2008 and over 200 million in 2014, it is expected to grow up to 50 billion in 2020. Along with communication and integration challenges, security is one of the more important areas that need to be deled with regarding M2M.

The architecture of M2M systems can generally be divided into 3 layers.

1. Terminal layer - contains the access gateway , area network and M2M nodes, M2M enabled devices
2. Network layer - responsible for transmitting data between the other two layers
3. Application layer - contains the application that utilizes the M2M system

Security issues in M2M systems are similar to ones found in providing security and privacy in communication over other networks, the internet... Additional problems that are more specific to M2M occur in the Terminal layer. Devices could potentially be easily accessible to attackers. This means that they could be tampered with or be controlled by attackers and false data could be injected threatening the overall performance of the M2M system and application.

M2M systems in the IoT context provide the means to build applications that can further the developments in many scientific areas along with bettering personal quality of life. Solving security issues and the general standardisation of undefined aspects in communication, as well as the development of quality and publicly availably solutions are the future steps that will enable the wide commercial use of these technologies.

Work by the authors of can provide a more detailed overview in M2M.

## Big Data

Storing, processing, accessing and managing vast amounts of data with unreliable or complex structure all fall in the term Big Data. Although the term refers only to a large amount of data, the challenges that come with handling and using of it also come hand in hand with this term. Big data is often described with the 4 or 5 Vs of Big Data (depending on different sources) as can be seen in the works of [11] [12] and can be seen in Figure 1.



Figure . The 5 Vs of BigData

**Volume** refers to the amount of information or data that is being generated and needs to be handled. Because of the sheer amount or just the type, traditional systems (referring to RBDMS) don't offer appropriate solutions and different methods/methods need to be taken into account. The authors of [11] predict that the size of the data being generated to reach the range from petabytes to zettabytes.

**Variety** refers to the data's structure. It can vary from a traditional sense of well structured and predictable data to semi-structured or unstructured and/or changing, coming from a variety of resources like Documents, email, Web Pages, Sensor Networks, Social Media etc.

**Velocity** refers to the rate of data flow. This is quite an open definition encompassing both the rate of data coming from different sources, but also rate of data flow in general.

**Variability** refers to the inconsistence of velocity in general. These is an issue that is hard to deal with and is best understood when thinking of the usage of social networking.

**Value** User can run certain queries against the data stored and then user got important results from the filtered data obtained and can also rank it according it the dimensions.

The authors of also a added **Complexity** to this as an important and sometimes forgotten aspect referring to the complexity of linking, matching, cleansing and transforming of data which is coming from various sources.

Along with fundamental challenges in Big Data, regarding functional issues, security has to be taken into account if implementations are to be realized. The biggest security challenge in Big Data is as identified in [14] is the protection of user's privacy. Vast amounts of personal identifiable information (PII) that are stored in unstructured databases (NoSQL) means that the location of all information is not always known unambiguously and even direct access is somewhat abstracted. Leaving everything as is and without applying security measures such as Access Control leaves things open for abuse.

## NoSQL

NoSQL, or otherwise known as "Non only SQL" refers to databases or data management systems which are designed to handle data management problems where conventional RDBMS solutions cannot cope for various reasons. These problems are usually related to: handling large amounts of data and the processing of it, high number of operations, specific types of operations or needs and others. Commonly, NoSQL systems are designed for large scale data storage and parallel processing over a large number of servers. Some systems provide APIs that support SQL or SQL-like languages and convert them into native non-SQL languages and use mechanisms different to ones in RDBMS. Because they provide the ability to handle large amounts of data it usually comes at the price of fully ACID (Atomicity, Consistency, Isolation, Durability) characteristics. This can be explained by the CAP (strong Consistency, high Availability, Partition tolerance) theorem which can be seen in more detail in , and because of this most systems can be described as BASE (Basically Available, Soft-state, Eventually consistent).

### Types of NoSQL databases

NoSQL databases can be classified in four basic categories as done in [16].

* Key-Value stores
* Document databases (or stores)
* Wide-Column (or Column-Family) stores
* Graph databases

Key-Value stores

These storage systems are organized in simple, standalone tables organized like "hash tables". The items stored in tables are key-value pairs where the key is a alpha-numeric identifier and the value is one or a set of values associated with that identifier. As the organisation of table is a "hash table" the limitation that is present is that they are usually limited to only "exact match" type of queries or allowing "<,>" type of operations with a significant reduction in speed. On the other hand read operations are very fast, as to be expected from a hash table data set, and because the keys can also be viewed as the addresses of the value wanted to be retrieved, even data from the same table can be distributed over several locations so these storage systems linear linear characteristics regarding scalability.

Document databases

Document based storage systems, as their name implies, are designed to store data in documents. They use standard data exchange formats such as XML, JSON or BSON to store the data in documents and as can distribute these documents on multiple locations. These are considered scheme-less databases because the storage format or storage data structure can be loosely defined. Single columns or single data entries can house hundreds of values and the number or type of values stored can vary from row to row. These are good for storing and managing big collections of documents containing significant amounts of data like text documents, emails, XML documents or objects containing large amounts of values and data. Along with that they are also convenient for storing sparse data collections because of their schema-less data structure. This means that the usual filling out with null values (that is traditionally done in RDBMS) is not necessary and means that the overall amount of space used is correlated to the amount of data stored inside the database. These solutions offer great scalability, unlike key-value based stores allow multiple "< >" types of comparators and both keys and values are fully searchable. Although they can offer MapReduce [17] features they tend to have slow response times to queries. This reason is because fetching data with multiple set parameters for values means reading and parsing data from whole documents.

Wide-Column Stores

Wide-Column (or Column-Family) stores are somewhat in between document based and key-value based storage systems. They have a structure similar to a key-value structure but allow multiple values and require at least one identifier column which fills the role of a primary key. They can form multiple indexes upon other values and allow "equal type" comparisons over the value attributes. Because of the similarity to key-value based systems they share the same faults regarding "< >" types of operations. The similarity to document based systems comes because they are distributed. The key value can be used to distribute data from a table to multiple locations. This offers good characteristics regarding scalability. Reading and writing operations are fast so they are specially suited for MapReduce operations and parallel processing of large amounts of data which is their main purpose and use.

Graph Databases

Graph databases, by basic concept are relational databases but still are very different from RDBMS in the sense that they also have relations. The relations themselves can be considered as more important because these are used when we mainly need to store date regarding the relationships and dependencies between objects rather than information about the objects themselves. They store data similar to object-oriented databases as use objects as network nodes which have relationships (edges) and properties or object attributes stored as key-value pairs. The relationships can also have different attributes or properties attached to them. They are suited for storing and visualizing data regarding graphs, networks etc.

### General overview of the technologies available at the moment

This section contains an overview of the current "popular choices" in NoSQL data storage and management systems, a brief comparison and conclusion.

Hadoop

This Apache project is a platform for developing open-source software for solving scalability and processing problems in the context of large quantities of data. Data storage supported by Hadoop falls in the wide column paradigm family of NoSQL systems. The platform has a large developer community and many open projects and because of that it is one of the biggest and fastest evolving platforms. On the Hadoop website it is stated that "The Apache Hadoop project develops open-source software for reliable, scalable, distributed computing" [18]. It is also stated that it is essentially a framework that allows distributed processing across clusters of computers, it is designed for scalability and can easily be scaled from one server to thousands of machines, it handles failures on the application layer and as a result provides a highly-available service on top of clusters, regardless of individual failures on machines inside the cluster.

These are the projects main modules as stated on it's official webpage [18]:

* Hadoop Common: The common utilities that support the other Hadoop modules.
* Hadoop Distributed File System (HDFS™): A distributed file system that provides high-throughput access to application data.
* Hadoop YARN: A framework for job scheduling and cluster resource management.
* Hadoop MapReduce: A YARN-based system for parallel processing of large data sets.

Apache Hive

Hive is one of the open source project developed on top of Hadoop. It is a mainly a data warehouse system. The list of organisations using Hive as stated on the official website [19] include: eBay, Facebook, LinkedIn, Spotify, Taobao, Tencent, and Yahoo!. As an open source project, Hive has a strong technical development community working with widely located and diverse users and organizations. Hive was originally designed as a translation layer on top of Hadoop MapReduce. It exposes its own dialect of SQL to users and translates data manipulation statements (queries) to a directed acyclic graph (DAG) of MapReduce jobs [19].

Hive defines a simple SQL-like query language, called QL, that enables users familiar with SQL to query the data. At the same time, this language also allows programmers who are familiar with the MapReduce framework to be able to plug in their custom mappers and reducers to perform more sophisticated analysis that may not be supported by the built-in capabilities of the language. QL can also be extended with custom scalar functions (UDF's), aggregations (UDAF's), and table functions (UDTF's). Hive does not mandate read or written data be in the "Hive format" — there is no such thing. Hive works equally well on Thrift, control delimited, or your specialized data formats. Please see File Formats and Hive SerDe in the Developer Guide for details. Hive is not designed for OLTP workloads and does not offer real-time queries or row-level updates. It is best used for batch jobs over large sets of append-only data (like web logs). What Hive values most are scalability (scale out with more machines added dynamically to the Hadoop cluster), extensibility (with MapReduce framework and UDF/UDAF/UDTF), fault-tolerance, and loose-coupling with its input formats. Components of Hive include HCatalog and WebHCat. HCatalog is a component of Hive. It is a table and storage management layer for Hadoop that enables users with different data processing tools — including Pig and MapReduce — to more easily read and write data on the grid. WebHCat provides a service that you can use to run Hadoop MapReduce (or YARN), Pig, Hive jobs or perform Hive metadata operations using an HTTP (REST style) interface [20].

Apache Spark

Spark is also an Apache open source (since 2010) project. It is a fast and general processing engine compatible with Hadoop data. It can run in Hadoop clusters through YARN or Spark's standalone mode, and it can process data in HDFS, HBase, Cassandra, Hive, and any Hadoop InputFormat. It is designed to perform both batch processing (similar to MapReduce) and new workloads like streaming, interactive queries, and machine learning [21]. It is built around speed, ease of use, and sophisticated analytics. It was originally developed at UC Berkeley in 2009. Databricks was founded by the creators of Spark in 2013. The engine runs in a variety of environments, from cloud services to Hadoop or Mesos clusters. It is used to perform ETL, interactive queries (SQL), advanced analytics (e.g. machine learning) and streaming over large datasets in a wide range of data stores (e.g. HDFS, Cassandra, HBase, S3). Spark supports a variety of popular development languages including Java, Python and Scala. Since its release, it has seen rapid adoption by enterprises across a wide range of industries. It has quickly become the largest open source community in big data, with over 400 contributors from 100+ organizations. It provides easy-to-use APIs for operating on large datasets. This includes a collection over 80 operators for transforming data and familiar data frame APIs for manipulating semi-structured data. It is packaged with higher level libraries, including support for SQL queries, streaming data, machine learning and graph processing. These standard libraries increase developer productivity and can be seamlessly combined to create complex workflows.

Apache HBase

HBase is very much a distributed database and can be categorized in the wide column paradigm family of NoSQL. Technically speaking, HBase is really more a "Data Store" than "Data Base" because it lacks many of the features you find in an RDBMS, such as typed columns, secondary indexes, triggers, and advanced query languages, etc.

However, HBase has many features which supports both linear and modular scaling. HBase clusters expand by adding RegionServers that are hosted on commodity class servers. If a cluster expands from 10 to 20 RegionServers, for example, it doubles both in terms of storage and as well as processing capacity. RDBMS can scale well, but only up to a point - specifically, the size of a single database server - and for the best performance requires specialized hardware and storage devices. HBase features of note are:

* Strongly consistent reads/writes: HBase is not an "eventually consistent" DataStore. This makes it very suitable for tasks such as high-speed counter aggregation.
* Automatic sharding: HBase tables are distributed on the cluster via regions, and regions are automatically split and re-distributed as your data grows.
* Automatic RegionServer failover
* Hadoop/HDFS Integration: HBase supports HDFS out of the box as its distributed file system.
* MapReduce: HBase supports massively parallelized processing via MapReduce for using HBase as both source and sink.
* Java Client API: HBase supports an easy to use Java API for programmatic access.
* Thrift/REST API: HBase also supports Thrift and REST for non-Java front-ends.
* Block Cache and Bloom Filters: HBase supports a Block Cache and Bloom Filters for high volume query optimization.
* Operational Management: HBase provides build-in web-pages for operational insight as well as JMX metrics.

[HDFS](http://hadoop.apache.org/hdfs/) is a distributed file system that is well suited for the storage of large files. Its documentation states that it is not, however, a general purpose file system, and does not provide fast individual record lookups in files. HBase, on the other hand, is built on top of HDFS and provides fast record lookups (and updates) for large tables. This can sometimes be a point of conceptual confusion. HBase internally puts your data in indexed "StoreFiles" that exist on HDFS for high-speed lookups.

Apache Casandra

MongoDB

Arango DB

Oracle NoSQL Database

OrientDB

OrientDB is a newer NoSQL system (since XXXXX). This data management system is a mixture of document-based and graph paradigm. It stores data similar to document-based systems like MongoDB and combines it with the relations found in graph databases like INFNKVND.

Redis

Redis is a key-value based data store.

### Security issues

### Studies and Comparisons

### Conclusion

NoSQL database systems arose alongside major Internet companies, such as Google, Amazon, and Facebook; which had challenges in dealing with huge quantities of data with conventional RDBMS solutions could not cope [1]. They can support multiple activities, including exploratory and predictive analytics, ETL-style data transformation, and non mission-critical OLTP (for example, managing long-duration or inter-organization transactions). Originally motivated by Web 2.0 applications, these systems are designed to scale to thousands or millions of users doing updates as well as reads, in contrast to traditional DBMSs and data warehouses [13].

Computational and storage requirements of applications such as for Big Data Analytics, Business Intelligence and social networking over peta-byte datasets have pushed sql-like centralized databases to their limits [8]. This led to the development of horizontally scalable, distributed non-relational No-SQL databases. We speculate some of the major (primarily) uses of NoSQL Databeses: Large-scale data processing (parallel processing over 12 distributed systems); Embedded IR (basic machine-to-machine information look-up & retrieval); Exploratory analytics on semi-structured data (expert level); Large volume data storage (unstructured, semi-structured, small-packet structured) NoSQL is a large and expanding field, for the purposes of this paper - characteristics (features and benefits of NoSQL databases); classification (categories four on their features); comparison and evaluation (with a matrix on basis of few attributes- design, integrity, indexing, distribution, system) of different types of NoSQL databases; and current state of adoption of NoSQL databases. This study report motivation to provide an independent understanding of the strengths and weaknesses of various NoSQL database approaches to supporting applications that process huge volumes of data; as well as to provide a global overview of NoSQL databases [16].

In the age of information technology, data is a very important to extract the useful information. It is obvious that data exists in different format. The processing of big data is still a challenging task. There is no universal tool which can handle enormous and data of various formats. Document oriented, Key-Value pair, Column and graph type of NoSQL databases are developed to handle this variety of data. The summarized discussion about different NoSQL databases is helpful in selection of suitable NoSQL database.

## Access Control

### General overview

### Types of access control

IBAC

RBAC

Diogo's work

ABAC

Other

### Comparisons

### ABAC in more detail

### XACML and JSON

### Current Technologies and open source solutions

### Conclusion

## SMARTIE

### Brief Overview

### General Architecture

### Goals of SMARTIE

### Current state

use cases and current accomplishments

### Future plans

## Other related work

# Temporary 3

## Temporary 31

### Temporary Conclusion

Companies such as Google, Facebook, Amazon... etc. are investing a lot of time, effort and money in solving the challenges regarding IoT, Big Data, Access Control, Security in all of these areas and more because future steps in the commercial technological aspect in general point to the integration of microcontrollers or computers in general into almost every device and everyday item or can be integrated into infrastructure, factories, farms, production facilities ect. This leads to an IoT which leads to Big Data problems which are being addressed by NoSQL data management systems. Along with the fundamental problems like infrastructure and having solutions that can cope and handle everything, security and privacy of all of that data is an issue that needs to be addressed for "real world" applications to be acceptable, safe and successful. ABAC using the XACML/JSON standard from OASIS is one of many possible solution/routs that can be taken regarding the solving of this problem. Compared to other solutions it offers exceptional security if taken into account the minimum amount of human effort needed for managing and updating policies. The implementation of a standardized solution means that modules can be taken and ported to other applications easily and used in other areas such as web and mobile applications and effectively addressing half of the issues from the OWASP current top ten list without relying on individuals to take in consideration security issues one by one.

the whole concept of SMART

SMARTIE is a project that embraces all of these areas in the goal of creating an infrastructure and system that will have a significant impact easing and bettering the management of cities in general.

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