

Adapting Property Graph Model to Overcome Modeling Challenges in Internet of Things (IoT)

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Abstract — Internet of Things requires efficient real time data collection and faster execution techniques to meet the real world networked society use cases. The essence of this paper is to show that Property Graph Model can be applied in prominent for capturing and processing data from IoT applications, functionalities and use cases. Networked society with all connected devices will generate large amounts of data because physical objects are embedded with electronics, software, sensors, and network connectivity, which enables these objects to generate large amount data. These large volumes of data should be stored in a big data, such as a key-value store or a map of map etc. Bigger challenge in this is to manage the relationship between all the different devices in the IoT with data coming from so many different endpoints from different physical objects. With market leaders in IoT predicting 50 billion connected devices by 2020, modeling IoT data in an efficient way is a real challenge.

Index Terms—IoT, Networked Society, Big Data, Big Data analytics

INTRODUCTION

With the number of connected devices increasing exponentially and with the advancement in computer and communication technologies, the rate of the data generated is growing exponentially. And it is not just the data but the relationship between more than 50 billion devices and understanding these relationships is going to be as complicated as understanding the different devices itself. Generated data from each device and the relationship between these devices depends on many factors.

- *Behavior of the device and its intended application:* Each device is intended to perform a specific operation in a networked society. Data that is generated from a self moving car is totally different from the data that is generated in a smart agriculture field. Same way a home automation data is different from the Parking space detection in a smart city. In each of the cases the data is so heterogeneous that it does not have any fixed pattern.
- *Dynamic and Rapidly changing Systems:* Data generated and collected in IoT depends on the selected IoT use cases. All the devices in the networked society are with dynamic and rapidly changing systems. Upgraded devices and new applications are regularly coming up in the market and each of these devices needs to sit seamlessly into the network. This demands a data model that can evolve along with the networked society without changes in the underlying database and

without impacting application that are already being used.

- *Advancements in smart devices and applications:* With 4G already in place and 5G well in talk and smart-phones, tablets and all the digital devices, along with different smart applications, have significantly contributed in generating data in different formats.

CHALLENGES IN MODELLEING IOT DATA

- *Complexity of data with devices on multiple platforms:* With so many different devices connected in a large networked society , there will be large number of protocols, different APIs, hence there will be lot of challenges in building the relation between all data from the different systems. Some of the devices in the networked society will have legacy and proprietary protocol and data models, where as some of the devices from the brand new IoT players are yet to bind their systems to any of the standards just to speed up their implementation in order to achieve early to market. With open source standards picking up multiple new standard evolves based on different data capabilities
- *Data Security:* There is no defined security model employed on the devices in internet of things. Some of the devices from less know vendors have no security at all. With integration of these device with more secured devices, the less secured devices can access data from more secured devices and hence making whole system prone to tempering.
- *Data Privacy:* With so many devices connected it is very difficult to control the access and clearly define the ownership for the shared data. There is no standard compliance defined for the data privacy in internet of things. All the device vendors are yet to be regulated on the data privacy policies.

MODELEING DATA IN IOT

It is important to choose right database for IoT applications. This database must support dynamic data modeling. With so many new vendors with all new devices it is important add them to the network continuously. This needs a modeling technique which can evolve along with the network evolution zero application downtime and a modeling which can scale horizontally. This dynamic modeling requirement straightway rules out traditional database technologies as it depends on fixed predefined schema(SQL Model).

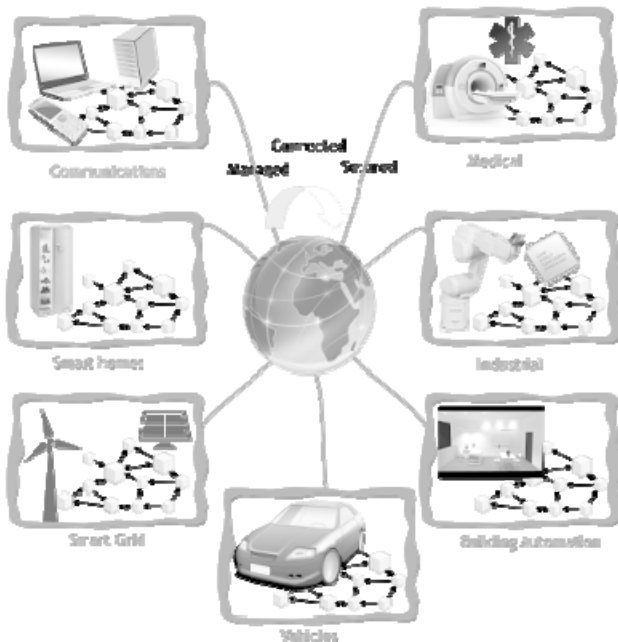


Figure 1 Connected Devices in IoT

IoT needs a flexibility where new devices with new data model can be easily plugged in. Along with the easy of plug-in, modeling should also take care of performance and scalability aspects of IoT.

PROPERTY GRAPH MODEL

Property Graph Model is designed to model and navigate data, with extremely high performance with connected nodes and relationships.

A typical IoT consists of connected devices which can be called as networked society. Devices will have relationships with different devices.

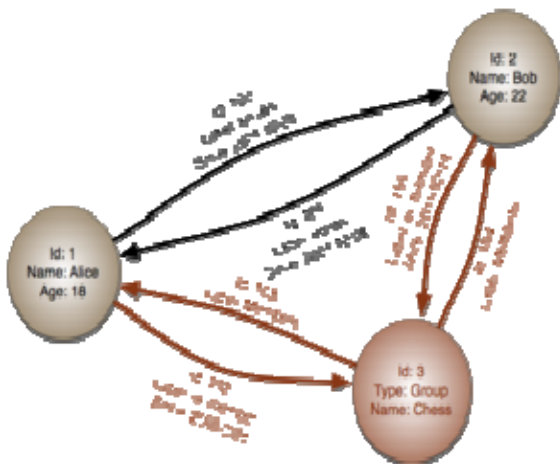


Figure 2 Property Graph Model Structure

Each device will have following behavior.

- A unique identifier.
- A set of outgoing relationships to other devices.
- A set of incoming relationships from other devices.
- A collection of properties defined by a map from key to value.

Each relationship will have following behavior.

- A unique identifier.
- An outgoing tail device.
- An incoming head device.
- A label that denotes the type of relationship between its two devices.

Property Graph Model consists of following component.

Graph: An object that contains of set vertices and set of edges.

Element: An object that can have any number of key/value pairs associated with it (i.e. properties). This element will either reside in Vertex or Edge.

Vertex: An object that has incoming and outgoing edges. Each vertex will have following behavior.

- A unique identifier.
- A set of outgoing edges.
- A set of incoming edges.
- A collection of properties defined by a map from key to value.

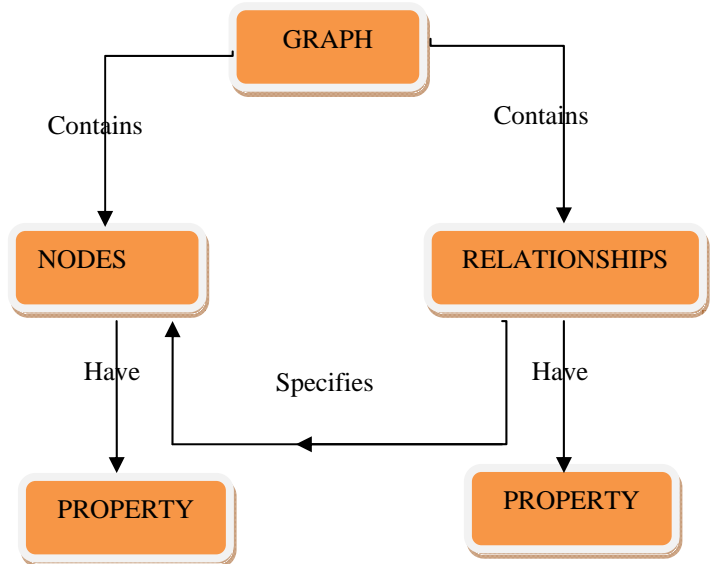


Figure 3 Property Graph Model Components

In IoT every node is connected to few other nodes. For example, the devices and subscribers may be depicted on a Google map, bringing the device, subscriber communication history, and location into a single graphs. Connected, Managed and Secured s are the actual relationship between entities: and that includes all the information, like direction, type, quality, history etc. These attributes can be represented, in a property graph model, object as an part of each relationship. In this context, attributes in relationship describe each connection. Attributes may describe when the relation was created, the type of relation, the data related to the relationship etc. The attributes of relationship may change quickly.

It is possible to represent a hierarchical structure with attributes for both nodes and relationships in normal database systems; it is more practical to use the property graph model in all the latest applications because of the performance. Property graph model can process complex, multidimensional connected network with large number of connections in a very quick time

PROCESSING IOT DATA USING PROPERTY GRAPH MODEL

Amount of data that IoT will generate is massive because each sensor and connected device continuously generates large volume of data and it also shares that data with the other devices in the network. These large volumes of data need not be stored in the tradition databases by processing it. Instead it can be stored as an unstructured data as Big Data or in Hadoop eco system.

Data is neither fully structured nor fully unstructured and hence there needs to bring a balance between storage and processing. Better way is to achieve this in one way is to use the big data infrastructure to store the data and advance analytical processing tools for data analytics. But this option is possible only when IoT application needs the data in the offline mode.

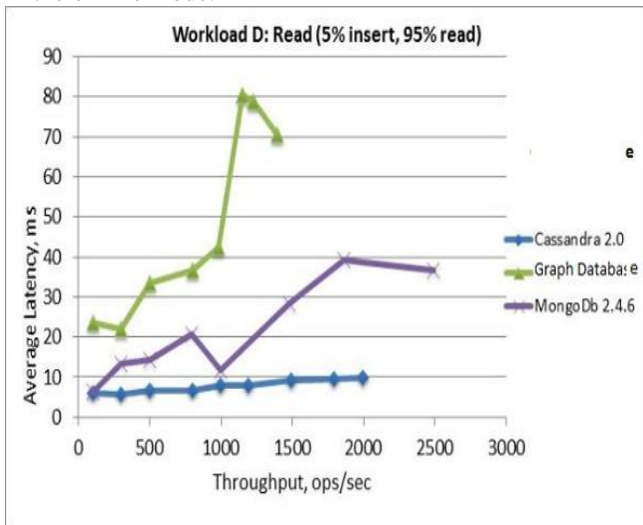


Figure 4 Performance Matrix of Graph Database against other DBs

In the real time streaming data analytics with dynamic data modeling with data driven modeling technique is needed. Property Graph Model provides a very efficient way of accessing entities and relationship with all sorts of filtering and column indexing hence providing efficient mechanism for high performance data processing and data access. Each data that is coming from a device need not be related to each and every data that is coming from other devices, whereas the devices themselves should be related to other devices and these devices and relationship should be managed as a whole. This can be easily achieved by graph structure.

CONCLUSION

Property Graph Model has enormous potential to improve overall IoT data modeling. This is so because it provides sophisticated technology to get high performance and easy maintenance without having schema hassles but still maintain all the relationship and constraints. Looking at various applications and usefulness of Property Graph Model we can be sure that in the future we'll see the rapid, widespread implementation and use of it across the Internet of things. Good data modeling technique at the time of initial deployment will lead easy update of the models as and when network evolution happens.

In the proposed model we are taking advantage of dynamic data model update and hence developing easy modeling technique. Moreover, the model also has easy processing of the network data with all the relationship. The big challenge of managing the connections, or relationships, present in IoT can be solved using Property Graph Model. Property Graph Model has evolved in a way to represent connected systems, and hence graph databases are a natural choice for the vast volumes of dynamic data that IoT produce.

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