The Search for New Database Solutions for Spectrum Management

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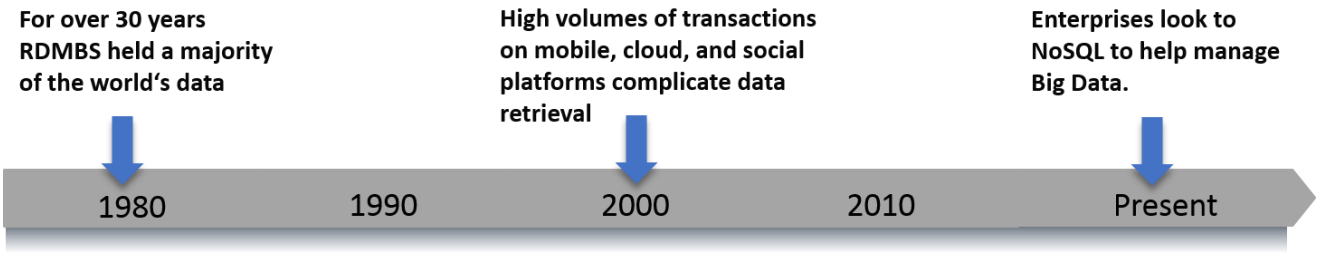
Abstract

Database preparation and administration has been undergoing significant changes due to the rise in popularity of mobile social media applications such as Facebook and Twitter. These popular social media applications have leveraged the advantages of the NoSQL or "Not Only SQL" movement for "Big Data" storage. Consequently, enterprise type organizations in various industries have begun to take notice of the rise in popularity of NoSQL and have begun adopting non-relational data models into their data management architecture. This document will focus on how NoSQL can provide advantages for spectrum regulatory organizations as well as briefly discuss potential drawbacks.



The Search for New Database Solutions for Spectrum Management

As stated in ITU-R SM.1370-11, inclusion of a Relational Database Management System (RDBMS) is necessary for any modern spectrum management system. However, the reality is that in most cases, a pure RDBMS is not always a sufficient solution for a national spectrum regulatory organization. For many IT enterprise customers, such as a national spectrum regulatory organization, constantly evolving IT and communications technologies and changing legal requirements demand a more flexible and scalable data model.

The following is a list of common requirements and tasks that spectrum regulatory organizations have for the implementation of a centralized database. Many of these requirements expose practical limitations of a pure RDBMS based architecture for spectrum management:

- Migration and consolidation of data from undocumented legacy systems;
- Regular introduction of updated equipment parameter fields to cover the emergence of new telecommunications technologies that need to be registered and stored in a central repository;
- Rapidly increasing amount of technical and administrative data to be stored and analyzed;

[1] RECOMMENDATION ITU-R SM.1370-1: Design guidelines for developing advanced automated spectrum management systems, 2001

- Unique business processes that change regularly (new billing legislation, licensing business processes, etc.);
- Fixed delivery deadlines;

For these reasons as well as many others not listed in the interest of brevity, alternate solutions for management of data pertaining to spectrum regulation need to be identified.

A new data model has been attracting attention for enterprise system implementations with requirements for managing "Big Data". Non-relational or "Not Only SQL" databases (NoSQL databases for short) are gaining steam in all manner of enterprise software deployments including popular social media applications such as Twitter, Facebook and Instagram. A relational data model structure could never handle the dynamic nature in which communications are sent through most social media sites. A system architect could never predict the constantly changing field parameters that would be sent through a Twitter feed. NoSQL databases can offer several benefits to spectrum regulatory organizations. In the following paragraphs we will examine some of the advantages that a NoSQL database can offer to a major spectrum regulatory organization as well as discuss some of the drawbacks. Ultimately, there may not exist a single data model format that would be best suited to cover all the needs of a spectrum regulatory organization. But it is always worthwhile exploring other options.

Summary Description of NoSQL

According to Wikipedia, NoSQL databases provide, "a mechanism for storage and retrieval of data that use looser consistency models than traditional relational databases in order to achieve horizontal scaling and higher availability." A NoSQL database substitutes the task of predicting a rigid data structure composed of multiple entity tables and fixed fields with creating versatile key-value pair stores as needed. As information is introduced into a NoSQL database, it is entered as a new record in a collection of records rather than a record in a pre-defined table structure. As a result, a pre-defined data structure composed of multiple entity tables and pre-defined fields is unnecessary. With NoSQL one just has document repositories. Below is an example of a Document Collection in a typical NoSQL database. Each key and value are distinguished by quotations:

```
{
    "_id": ObjectId("4efa8d2b7d284dad101e4bc7"),
    "Last Name": "PELLERIN",
    "First Name": "Franck",
    "Date of Birth": "09-19-1983",
    "phoneNumber": [
        {
            "type": "home",
            "number": "212 555-1234"
        },
        {
            "type": "fax",
            "number": "646 555-4567",
            "verified":  false
        }
    ],
    "Address": {
        "Street": "1 chemin des Loges",
        "City": "VERSAILLES"
    },
    "Months at Present Address":  37
}
```

Advantages for Spectrum Management

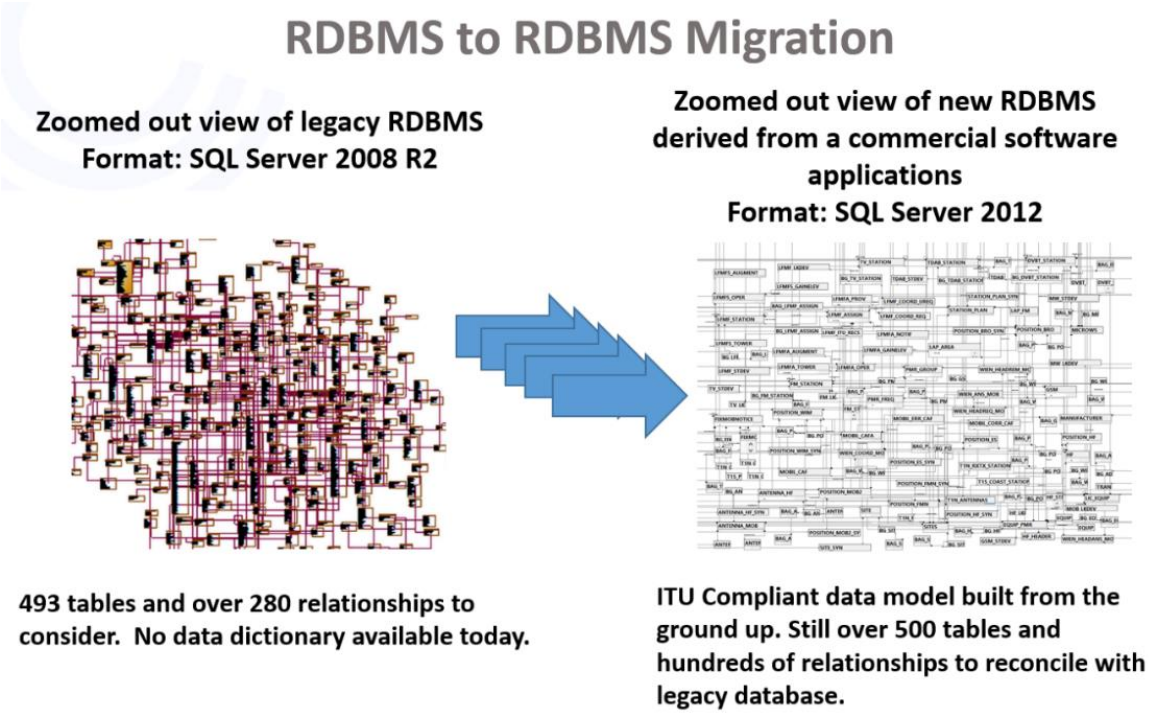
Data Migration

The data migration phase is crucial to the successful implementation and delivery of a spectrum management system. Often times the entire project can hinge on the completion of this phase before being able to complete other development phases and commencing with final implementation.

The SQL approach organizes the various radio technologies (such as point-to-point, broadcast, PMR, cellular, satellite, amateur, etc.) that the spectrum management system must manage into services and sub-services. The consequence of organizing technical information regarding radio communications systems in this way is that the architect winds up creating a table for each radio service and sub-service. What can result is an increasingly complicated data layer composed of several abbreviated tables.

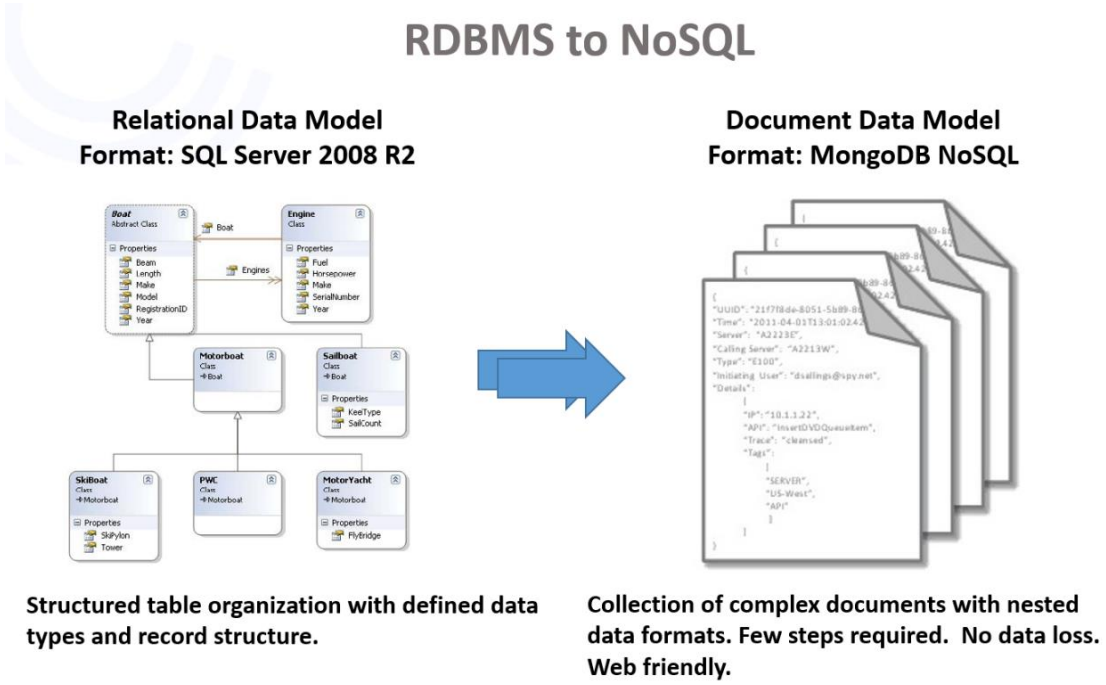
As a result, the entire implementation process for a spectrum management system no longer retains its transparency before the end-user. As the users wait for the new RDBMS data structure to be defined and the database to be populated, the architect can lose the opportunity to have them adopt the system in a convenient manner.

The spectrum management system should have the flexibility to add new radio technologies and their associated parameters and requirements in a quick and efficient way without resulting in an overly complicated data layer. In the figure below, two RDBMS data layers are compared with each other. In each case, roughly 500 tables and several hundred relationships must be reviewed and understood before a data migration can be completed:



Furthermore, it is common for a spectrum management organization to be unable to provide dedicated or extensive support on the legacy systems they wish to have migrated to a new database. The software vendor has to either guess at an implementation schedule somewhat blindly, or base their delivery assumptions on other criteria. In the diagram above, the multiple arrows represent an unforeseen number of steps necessary to complete the data migration between one established RDBMS to another.

By proposing to work with a NoSQL data structure from the beginning (possibly integrating with an RDBMS down the line), it is much easier for the vendor to propose a safe implementation timeframe that lowers project risk substantially. Below is a figure illustrating the relative ease there is in completing the data migration to a more flexible data model such as NoSQL:



Hardware Scalability

As transaction rates increase, the need for available hardware resources to support expanding data repositories increases dramatically. NoSQL databases are designed to expand horizontally rather than vertically over low-cost computer clusters. No need for "scaling up" with bigger, more expensive servers.

Doesn't Eliminate any Options Going Forward

In many cases, enterprises use a combination of No SQL and RDBMS for their data management.

Concluding Thoughts

While this paper advocates the strengths of NoSQL for enterprise data management, there are potential drawbacks to adopting any single format for centralizing data. Given that the rise in popularity in NoSQL for the enterprise is recent, there can be difficulty in finding personnel with the expertise to consult, configure, and maintain a NoSQL architecture. Also, because NoSQL is still considered a new architecture for many developers, there is a noticeable degree of unease amongst IT managers in adopting a pure NoSQL architecture going forward. The unease in quick adoption and lack of available expertise are sticking points amongst IT managers in developing countries where any kind of specialized expertise is sparse.

Also, while the rigid structure of an RDBMS lends itself inflexible for horizontal scaling and adaptation to changing requirements, only an RDBMS can provide certain advantages in data management

such as the indexing of information to facilitate simple queries. In certain cases, where the database structure doesn't require a lot of modification or any at all, an RDBMS solution is completely suitable. For these reasons, a NoSQL/RDBMS hybrid solution is common with large enterprises and may be the best solution for spectrum regulatory organizations that wish to implement a new spectrum management system.