EPC Object Code Mapping Service software architecture: web approach

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Abstract

The explosive growth of EPC adoption has spurred not only the development of the RFID technology but also fostered the development of software that ensures functioning of the net ecosystem. This adds to importance of Object Code Mapping Service (OCMS). The existing approaches to OCMS implementation fail to provide for global scalability. This paper tackles the issue of direct and reverse search in an OCMS system. A problem of enabling multipoint access and global scalability is described. Linking a comprehensive object description to the EPC code is substantiated. An approach to the OCMS functionality and architecture capable to meet these requirements is described. We present a suite of web technologies that allows the development of globally scalable, multi-point accessible OCMS system providing for efficient search. The presented architecture design is aimed at support of the global EPC database and affords efficient direct and reverse search of object codes and object descriptions by means of the Internet.

EPC network and its principal constituents

Efficient application of EPC leans upon world-wide assignment of globally unique codes to real-world objects. When every organization engages in individual development of its own coding system the resulting "local" model of application leads to losing many opportunities inherent in electronic identification, for example life-long support of the product as well as consumption and preferences statistics gathering. To ensure world-wide adoption of EPC, EPCglobal was set up working in cooperation with GS1– the global product code standard setter.

Current state of things in RFID-based information systems industry

At present "local" applications (primarily RFID-based) of electronic coding are gaining acceptance while methods of handling codes provided by readers are handed over to production systems and do not undergo standardization. Owing to this, software developers for ERP and CRM systems started to include RFID-related functionalities in their products. One example is the Dynamix line of Microsoft products that features such functionalities. Other well reputed vendors such as SAP and Oracle also announced similar capabilities. There are strong grounds to believe, though, that the use of proprietary RFID-based solutions in the development of production systems will hamper organization of efficient interoperation between such systems and preclude attainment of the anticipated effect from world-wide adoption of EPC. Keenly aware of the importance to include EPC data into the control of the production process of every individual enterprise, we nevertheless believe that preservation of the numbering format globally uniform and hence interpretation of object EPC identities globally unique is of equal importance. With this end in mind and starting from the EPC technology concepts, let us consider the base notion, which comprises all principle functionalities, that is EPC Network. Fig. 1 borrowed from [1] illustrates all essential components of the said network and their interrelation.

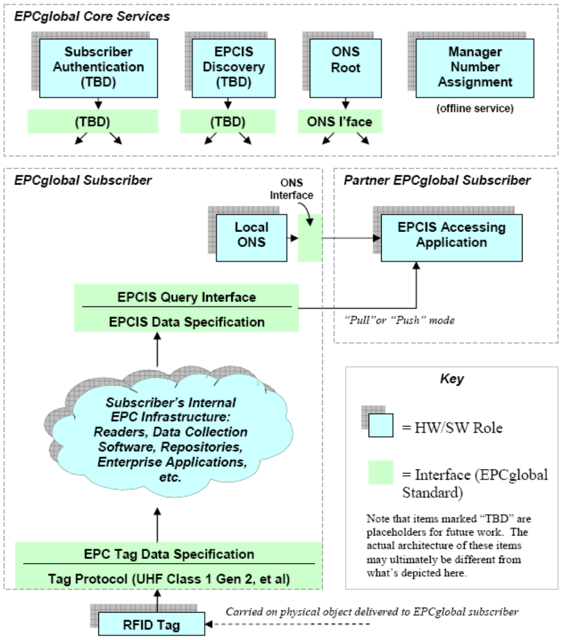

Fig. 1: EPC network architecture

Any local production system incorporates a more or less complete set of the above components. Additionally, every such system implements an object code mapping service (OCMS) intended to link object codes to descriptions of the objects. In the majority of production systems object descriptions (ODs) are character strings or complete text files describing the object. When the reader reads EPC from the RFID tag the code in the form of a query is forwarded to the database that keeps code mapping data for reading the object description and subsequent use of the information in the system business logic. The database replenishment is done by specific processes the simplest of which perform only code correctness verification while more sophisticated enter descriptions. Anyway, such databases are enterprise-specific and not fit for integration. In the global perspective, any object can move from one production system to another with the electronic code remaining the same and only the description changing as demanded by business processes. The global nature of the code and accessibility of descriptions to variegated business processes may prove instrumental in promotion of the world trade security and lawfulness of ownership change. Such application of EPC and associated web entities was patented by the authors [2] and presented in a number of publications [3,4].

An important system that allows object code mapping (OCMS) to network addresses of services providing information about objects is ONS (object name service) standardized by EPCglobal. From the standpoint of design and functioning ONS is similar to DNS with the exception that ONS operates with EPC codes instead of URLs. Just like DNS, ONS is designed for use in the global Internet. ONS ensures only partial EPC code mapping to the object description. The description proper is delivered by the service to which the ONS record points.
All the above may be regarded as a substantiation of the need to create a globally accessible uniform OCMS capable of finding matches between EPC codes and respective object descriptions. In addition to the ONS functionality such a system may store a description (or just a portion of it) for every object to enable description search by the object EPC code and vice versa the object search by its description.

Study of OCMS System functionality requirements

As follows from an examination of desired OCMS System functionalities, its main strength would be the capability to return object descriptions in response to queries in form of EPC codes. In what follows we refer to this function as Direct Search (OCMSDS). Simultaneously, in connection with the adoption of RFID and other location-aware technologies another no less important functionality would be search of an object (object EPC) by the clues available in its description. Suppose, for example, it is necessary to find out if medicine titled XXX with production date not earlier than ZZZ and available in YYY pills packs was released from the store. To perform this task, it is necessary to look through descriptions of all drugs kept at the store that contain the attributes XXX, YYY and ZZZ and return EPC codes of all objects that conform to the search criteria. Subsequent processing of the obtained result may provide an answer to the question "how many packs of the medicine meeting the said characteristics are available at the store". In what follows we will refer to such an OCMS Service as Reverse Search (OCMSRS). The crucial points for the functions described here are search time (or better the database size dependence of search time) and search reliability. The search reliability can be evaluated by the database-size dependent number of not found and wrongly found EPC codes.

Let us consider some other important functionalities of the OCMS System. To provide for the System global nature the service must be available to various geographically dispersed locations for both carrying out OCMSDS, OCMSRS and adding to the System new descriptions with related EPC codes (OCMS Insert or OCMSIN) as well as for removal of descriptions and respective EPC codes (OCMS Delete or OCMSDE). All the above procedures must be performable regardless of the time and the location of their origin. We refer to such service accessibility as multipoint accessibility. The global nature of OCMS causes another deployment requirement, i.e. global scalability of the system. The term global scalability is understood here to mean the unlimited ability to increase the size of the object description repository by the OCMSIN procedure only without causing the need of the database restructuring or reconfiguration. This of course does not free one from the necessity to take care of adequate storage media and computing power build up. Finally, let us mention another significant requirement. Different business processes require different prioritization of object properties available in object descriptions. In this perspective, OCMS must allow for complex query structures during OCMSRS while the descriptions storage method must allow easy selection of the necessary information without sacrificing the diversity of the description itself. For example, the ability to view a description calls for text and even multimedia components which must provide for efficient search of attributes that constitute the object multifaceted presentation. Below we refer to this OCMS system requirement as the support of multiview object description.

Base constructs for OCMS implementation

Let us present now the basic conceptual technologies that can help solve the problem of creating an OCMS system meeting the above said requirements. First, OCMS should be implemented as a web service accessible by means of the Internet. This helps achieve the goal of multipoint access. To provide for global scalability, the repository of descriptions should be implemented as a distributed file system where every object description is a XML document accessible at a unique URL. Such a document must include the object EPC code to make direct search (OCMSDS) possible. For search in such a system, every document is provided with a set of links to a number of other documents including those located on other servers of the system. This information is stored with every document and later in this paper is referred to as LinkList. The search mechanism for the sake of global scalability is also designed as a fully distributed system. An operating environment is installed on every server which keeps a finite number of XML documents (object descriptions). The operating environment ensures execution of OCMSDS, OCMSRS queries, OCMSIN, OCMSDE procedures and URL marking, calculation of a special metric that defines the proximity of two selected XML documents and transfer of the marker to the document keeping URL with the least metric value. Information about links (LinkList) is based on the metric and is organized so that close documents are separated from each other by a small number of link references. Such organization allows efficient search in big-size systems.

Search tasks are solved by a population of processors simultaneously attending to a multitude of queries entering the network. This ensures global scalability of both the storage and search capability. To meet the requirement of weak repository size dependence of search time, the search system employs special arrangement of pointers in every LinkList which assures a robust coherence of the entire document storage system and at the same time frail dependence of the path length between two arbitrary documents on the overall number of documents.

The OCMS system is capable of implementing the ONS functionality on a fully distributed P2P network. This makes it possible to depart from the tree-like server structure of a DNS-like system characterized by a single entry point and therefore pregnant with scalability issues triggered by an ever increasing number of objects and turn to a distributed limitlessly scalable structure.

System prototype development

To test the OCMS system concept and demonstrate its capability we have developed a distributed storage and search system prototype. The prototype system is comprised of a number of servers with XML file object descriptions and has means of the servers' interaction. The servers are interconnected in a P2P network which means there is no focal-point manager controlling the servers. Interoperation between the servers is done under the HTTP protocol, a standard information conveyance protocol in the Internet. Server-server and server-subscriber interaction messages circulating across the network are in the XML format. Descriptions stored on the servers form a transparent (with respect to the servers' net) P2P overlay network. Every network node keeps a set of links (URLs) to other nodes forming the network. The network is arranged in compliance with the principle of "small world" which makes it possible to promptly retrieve information even with the huge size of the network (when the amount of elements is comparable to the number of real-world objects.) The network dynamically grows as the number of added new descriptions increases.

Though, physically the network is comprised of servers that keep a multitude of XML descriptions, logically information exchange takes place between these descriptions which allows arbitrary distribution of descriptions among the servers with consideration for their reliability, performance etc.

The network of descriptions has the so-called entry points which are arbitrarily selected network nodes. Subscribers interact with the system by sending XML messages to and receiving replies from one of the entry points. Possible interaction types include node search by the EPC code or by other relevant information about the node, and addition of new nodes to the system. As a result the search returns a link to the necessary node or a list of links if search criteria imply several nodes matching the query.

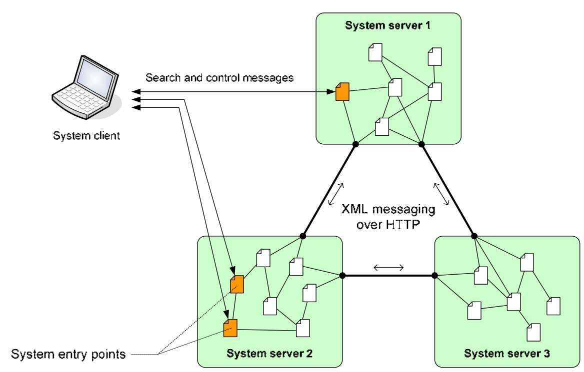

Fig. 2: OCMS prototype architecture

Conclusions

Based on the objective to develop a global system of EPC support, major OCMS service requirements have been examined in the paper and some essential characteristics suggested for their implementation. Basic software development principles for implementation of OCMS on a global scale have been developed. The suggested principles have been verified during the development and deployment of a prototype OCMS system.

References

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