The EPCglobal Architecture Framework

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Abstract

This document defines and describes the EPCglobal Architecture Framework. The EPCglobal Architecture Framework is a collection of interrelated standards for hardware, software, and data interfaces, together with core services that are operated by EPCglobal and its delegates, all in service of a common goal of enhancing the supply chain through the use of Electronic Product Codes (EPCs). This document has several aims:

- To enumerate, at a high level, each of the hardware, software, and data standards that are part of the EPCglobal Architecture Framework and show how they are related.
- To define the top level architecture of core services that are operated by EPCglobal and its delegates.
- To explain the underlying principles that have guided the design of individual standards and core service components within the EPCglobal Architecture Framework.
- To provide architectural guidance to end users and technology vendors seeking to implement EPCglobal standards and to use EPCglobal core services.

This document exists only to describe the overall architecture, showing how the different components fit together to form a cohesive whole. It is the responsibility of other documents to provide the technical detail required to implement any part of the EPCglobal Architecture Framework.

Audience for this document

The audience for this document includes:

- Hardware developers working in the areas of developing EPC tags and EPC-enabled systems and appliances, including devices to read and write tag data.
- Software developers working in the areas of developing EPC middleware and business applications that use, create, store and/or exchange EPC-related information.
- Enterprise architects and systems integrators that integrate EPC-related processes and applications into enterprise architectures.
- Participants of EPCglobal Working Groups (including Software Action Group, Hardware Action Group and all Business Action Groups) working on defining requirements and developing EPCglobal standards.
- Industry groups, governing organizations, and companies that are developing or overseeing business processes that rely on EPC technology.
- Members of the general public who are interested in understanding the principles and terminology of the EPCglobal Architecture Framework

Status of this document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. The latest status of this document series is maintained at EPCglobal. See `www.epcglobalinc.org` for more information.

This document is an EPCglobal approved document and is available to the general public.

Comments on this document should be sent to the EPCglobal Architecture Review Committee mailing list arc_request@epclinklist.epcglobalinc.org.

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1 Introduction

This document defines and describes the EPCglobal Architecture Framework. The EPCglobal Architecture Framework is a collection of interrelated standards for hardware, software, and data interfaces ("EPCglobal Standards"), together with core services that are operated by EPCglobal and its delegates ("EPCglobal Core Services"), all in service of a common goal of enhancing the supply chain through the use of Electronic Product Codes (EPCs).

The primary beneficiaries of the EPCglobal Architecture Framework are EPCglobal Subscribers and other Solution Providers. An EPCglobal Subscriber is any organization that uses EPCglobal Core Services, or participates in the EPCglobal Standards Development Process to develop EPCglobal Standards. EPCglobal Subscribers may be further classified as End-users or Solution Providers (or both). An End-user is an EPCglobal Subscriber that employs EPCglobal Standards and EPCglobal Core Services as a part of its business operations. A Solution Provider is an organization that implements for End-users systems that use EPCglobal Standards and EPCglobal Core Services. (A Solution Provider may or may not itself be an EPCglobal Subscriber.) Informally, the synergistic effect of EPCglobal Subscribers interacting with EPCglobal and with each other using elements of the EPCglobal Architecture Framework is called the "EPCglobal Network."

This document has several aims:

- To enumerate, at a high level, each of the hardware, software, and data standards that are part of the EPCglobal Architecture Framework and show how they are related. These standards are implemented by hardware and software systems in the EPCglobal Network, including components deployed by individual EPCglobal subscribers as well as EPCglobal Core Services deployed by EPCglobal and its delegates.

- To define the top level architecture of EPCglobal Core Services, which provide common services to all subscribers of the EPCglobal Network, through interfaces defined as part of the EPCglobal Architecture Framework.

- To explain the underlying principles that have guided the design of individual standards and Core Service components within the EPCglobal Network. These underlying principles provide unity across all elements of the EPCglobal Architecture Framework, and provide guidance for the development of future standards and new Core Services.

- To provide architectural guidance to end users and technology vendors seeking to implement EPCglobal Standards and to use EPCglobal Core Services, and to set expectations as to how these elements will function.

This document exists only to describe the overall architecture, showing how the different components fit together to form a cohesive whole. It is the responsibility of other documents to provide the technical detail required to implement any part of the EPCglobal Architecture Framework. Specifically:

- Individual hardware, software, and data interfaces are defined normatively by EPCglobal specifications, or by standards produced by other standards bodies. EPCglobal specifications are developed by EPCglobal membership through the EPCglobal Standards Development Process (SDP) [SDP1.1]. EPCglobal specifications are normative, and implementations are subject to conformance and certification requirements.

  An example of an interface is the UHF Class 1 Gen 2 Tag Protocol, that specifies a radio-frequency communications protocol by which a Radio Frequency Identification (RFID) tag and an RFID reader device may interact. This interface is defined normatively by the UHF Class 1 Gen 2 Tag Protocol Specification.

- The design of hardware and software components that implement EPCglobal specifications are proprietary to the vendors and end users that create such components. While EPCglobal specifications provide normative guidance as to the behavior of interfaces between components, implementers are free to innovate in the design of components so long as they correctly implement the interface specifications.

  An example of a component is an RFID tag that is the product of a specific tag manufacturer. This tag may comply with the UHF Class 1 Gen 2 Tag Protocol Specification.

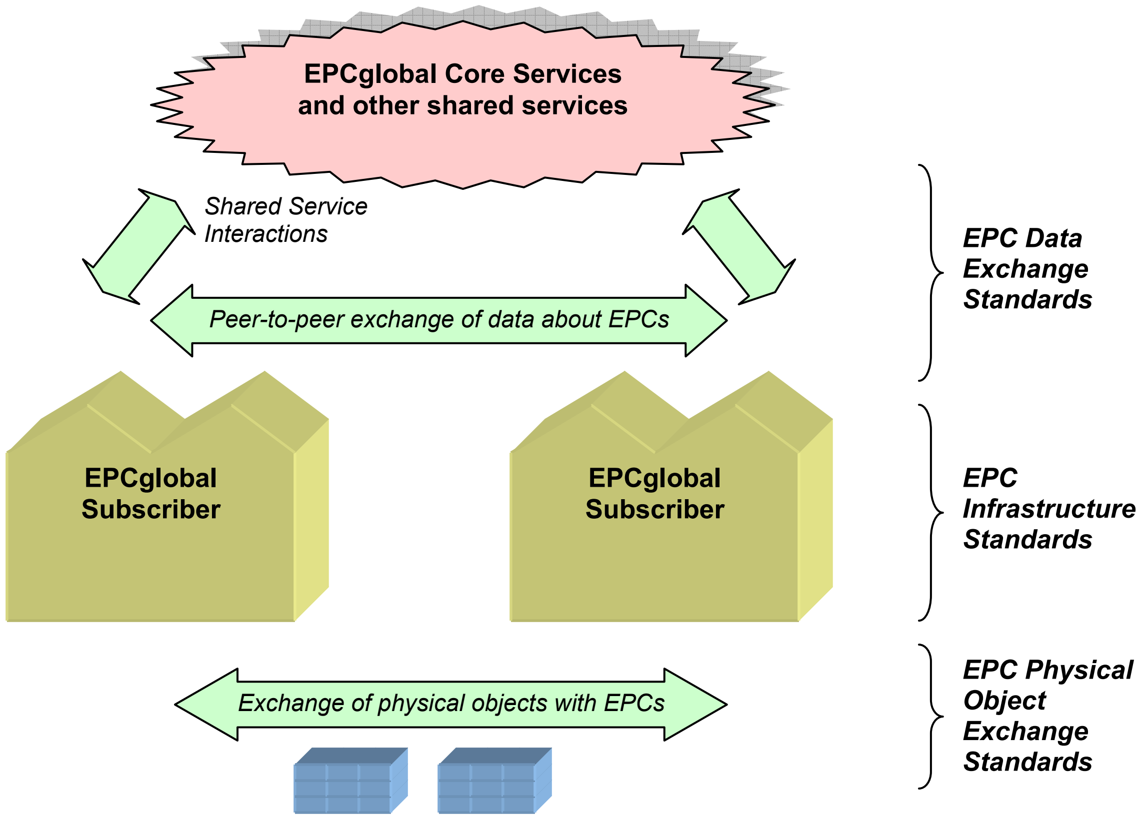
- A special case of components that implement EPCglobal specifications are components that are operated and deployed by EPCglobal itself (or by other organizations to whom EPCglobal delegates responsibility). These components are referred to as EPCglobal Core Services, and provide services to all EPCglobal subscribers. The design of these components is the responsibility of EPCglobal or its delegates, and design details may be made public at EPCglobal's discretion.

  An example of an EPCglobal Core Service is the Object Name Service (ONS), which provides a logically centralized registry through which an EPC may be associated with information services. The ONS is logically operated by EPCglobal; from a deployment perspective this responsibility is delegated to a contractor of ONS that operates the ONS "root" service, which in turn can delegate responsibility to other services operated by other organizations.

At the time of this writing, there are many parts of the EPCglobal Architecture Framework that are well understood, and for which EPCglobal standards already exist or are currently in development. There are other parts of the EPCglobal Architecture Framework that are less well understood, but where a need is believed to exist based on the analysis of known use cases. In these cases, the architectural approach has not yet been finalized, and therefore work on developing standards or designing additional Core Services has not yet begun (though architectural analysis is underway within the Architecture Review Committee). This document clearly identifies which parts of the EPCglobal Architecture Framework are understood architecturally and which parts need further work. This document will be the basis for working through and ultimately documenting the architectural decisions around the latter parts as work continues.

2 Architecture Framework Overview

The diagram below illustrates the activities carried out by EPCglobal Subscribers and the role that components of EPCglobal Architecture Framework play in facilitating those activities.



2.1 Architecture Framework Activities

In the diagram above, there are three broad activities illustrated, each supported by a group of standards within the EPCglobal Architecture Framework:

- *EPC Physical Object Exchange* Subscribers exchange physical objects that are identified with Electronic Product Codes (EPCs). For many end users of the EPCglobal Network, the physical objects are trade goods, the subscribers are parties in a supply chain for those goods, and physical object exchange consists of such operations as shipping, receiving, and so on. There are many other uses that are quite different than this trade goods model, but those other uses still involve the tagging of some object or objects. The EPCglobal Architecture Framework defines EPC physical object exchange standards, designed to ensure that when one subscriber delivers a physical object to another subscriber, the latter will be able to determine the EPC of the physical object and interpret it properly.

- *EPC Data Exchange* Subscribers benefit from the EPCglobal Network by exchanging data with each other, increasing the visibility they have with respect to the movement of physical objects outside their four walls. The EPCglobal

Architecture Framework defines EPC data exchange standards, which provide a means for one subscriber to share data about EPCs with another through direct peer-to-peer interaction, and which also provide access to EPCglobal Core Services and other shared services that facilitate these exchanges.

- *EPC Infrastructure* In order to have EPC data to share, each subscriber carries out operations within its four walls that create EPCs for new objects, follow the movements of objects by sensing their EPC codes, and gather that information into systems of record within the organization. The EPCglobal Architecture Framework defines interface standards for the major infrastructure components required to gather and record EPC data, thus allowing subscribers to build their internal systems using interoperable components.

This division of activities is helpful in understanding the overall organization and scope of the EPCglobal Architecture Framework, but should not be considered as extremely rigid. While in many cases, the first two categories refer to cross-enterprise interactions while the third category describes intra-enterprise operations, this is not always true. For example, an organization may use EPCs to track the movement of purely internal assets, in which case it will apply the physical object exchange standards in a situation where there is no actual cross-enterprise exchange. Conversely, an enterprise may outsource some of its internal operations so that the infrastructure standards end up being applied across company boundaries. The EPCglobal Architecture Framework has been designed to give EPCglobal Subscribers a wide range of options in applying the standards to suit the needs of their particular business operations.

2.2 Architecture Framework Standards

The following table summarizes all standards within the EPCglobal Architecture Framework in terms of the three activities described in the preceding section. A fuller description of each standard is given in Section 5. This table is intended mainly as an index of all current components of the EPCglobal Architecture Framework, not a roadmap for future work.

<table>
<tr><th>Activity</th><th>Standard</th><th>Status</th><th>Reference</th></tr>
<tr><td rowspan="5">Object Exchange</td><td>UHF Class 0 Gen 1 RF Protocol</td><td>(Note 4, below)</td><td>[UHFC0]</td></tr>
<tr><td>UHF Class 1 Gen 1 RF Protocol</td><td>(Note 4, below)</td><td>[UHFC1G1]</td></tr>
<tr><td>HF Class 1 Gen 1 Tag Protocol</td><td>(Note 5, below)</td><td>[HFC1]</td></tr>
<tr><td>UHF Class 1 Gen 2 Tag Protocol</td><td>Ratified</td><td>[UHFC1G2]</td></tr>
<tr><td rowspan="2">EPC Tag Data Specification</td><td rowspan="2">Ratified</td><td rowspan="2">[TDS1.1]</td></tr>
<tr><td rowspan="4">Infrastructure</td></tr>
<tr><td>Reader Protocol</td><td>In development</td><td>[RP1.0]</td></tr>
<tr><td>Reader Management</td><td>In development</td><td>[RM1.0]</td></tr>
<tr><td>Tag Data Translation</td><td>In development</td><td>[TDT1.0]</td></tr>
</table>

Activity	Standard	Status	Reference
	Application Level Events (ALE)	In development	[ALE1.0]
	EPCIS Capture Interface	In development	[EPCIS1.0]
Data Exchange	EPCIS Data Specification	In development	[EPCIS1.0]
	EPCIS Query Interface	In development	[EPCIS1.0]
	ONS	In development	[ONS1.0]
	EPCIS Discovery	TBD (Note 3)	(none)
	Subscriber Authentication	TBD (Note 3)	(none)

Notes for the "Status" column of the table above:

1. "Ratified" indicates a ratified EPCglobal specification.
2. "In development" indicates a specification whose development has been chartered and is underway within the EPCglobal standards development process
3. "TBD" indicates a technical area that is expected to be addressed within the EPCglobal Architecture Framework but where requirements are still under study within the Business Action Groups or the Architecture Review Committee.
4. Prior to the launch of EPCglobal in November 2003, the former Auto-ID Center published two UHF tag protocol specifications, referred to herein as UHF Class 0 Gen 1 and UHF Class 1 Gen 1. These specifications, which are not EPCglobal standards, are superceded by the UHF Class 1 Gen 2 protocol which was ratified by EPCglobal in December 2004.
5. Prior to the launch of EPCglobal in November 2003, the former Auto-ID Center also published an HF tag protocol specification referred to herein as HF Class 1. The business requirement for EPCglobal standardization of an HF tag protocol is being assessed at the time of this writing.

In the table above, the EPCIS Data Specification is shown as spanning the categories of infrastructure standard and data exchange standard. Likewise, the EPC Tag Data Specification is shown spanning the categories of object exchange standard and infrastructure standard, though in fact it also spans the data exchange category.

3 Goals for the EPCglobal Architecture Framework

This section outlines high-level goals for the EPCglobal Architecture Framework in terms of the benefits provided to EPCglobal Subscribers.

3.1 The Role of Standards

EPCglobal standards are created to further the following objectives:

- *To facilitate the exchange of information and physical objects between trading partners.*

  For trading partners to exchange information, they must have prior agreement as to the structure and meaning of data to be exchanged, and the mechanisms by which exchange will be carried out. EPCglobal standards include data standards and information exchange standards that form the basis of cross-enterprise exchange. Likewise, for trading partners to exchange physical objects, they must have prior agreement as to how physical objects will carry Electronic Product Codes in a mutually understandable way. EPCglobal standards include specifications for RFID devices and data standards governing the encoding of EPCs on those devices.

- *To foster the existence of a competitive marketplace for system components.*

  EPCglobal standards define interfaces between system components that facilitate interoperability from components produced by different vendors (or in house). This in turn provides choice to end users, both in implementing systems that will exchange information between trading partners, and systems that are used entirely within four walls.

- *To encourage innovation*

  EPCglobal standards define *interfaces*, not *implementations*. Implementers are encouraged to innovate in the products and systems they create, while interface standards ensure interoperability between competing systems.

3.2 Global Standards

EPCglobal is committed to the creation and use of global standards. This approach ensures that the EPCglobal Architecture Framework will work anywhere in the world and provides incentives for Solution Providers to support the framework. EPCglobal standards are developed for global use. EPCglobal is committed to making use of existing global standards when appropriate, and EPCglobal works with recognized global standards organizations to ratify standards created within EPCglobal.

3.3 Open System

The EPCglobal Architecture Framework is described in an open and vendor neutral manner. All interfaces between architectural components are specified in open standards, developed by the community through the EPCglobal Standards Development Process or an equivalent process within another standards organization. The Intellectual Property policy of EPCglobal is designed to secure free and open rights to implement EPCglobal Standards in the context of conforming systems, to the extent possible.

3.4 Platform Independence

The EPCglobal Architecture Framework can be implemented on heterogeneous software and hardware platforms. The specifications are platform independent meaning that the structure and semantics of data in an abstract sense is specified separately from the concrete details of data access services and bindings to particular interface protocols.

Where possible, interfaces are specified using platform and programming language neutral technology (e.g., SOAP messaging [SOAP1.2]).

3.5 Scalability and Extensibility

The EPCglobal Architecture Framework is designed to scale to meet the needs of each End-user, from a minimal pilot implementation conducted entirely within an End-user's four walls, to a global implementation across entire supply chains. The specifications provide a core set of data types and operations, but also provide several means whereby the core set may be extended for purposes specific to a given industry or application area. Extensions not only provide for proprietary requirements to be addressed in a way that leverages as much of the standard framework as possible, but also provides a natural path for the standards to evolve and grow over time.

3.6 Security

The EPCglobal Architecture Framework is designed to promote a secure environment for operations inside and outside a company's four walls. Security features are either built into the specifications, or best security practice is recommended.

3.7 Privacy

The EPCglobal Architecture Framework is designed to accommodate the needs of both individuals and corporations to protect confidential and private information. While many parties may ultimately be willing to give up some privacy in return for getting information or other benefits, all of them demand the right to control that decision. The EPCglobal Public Policy Steering Committee (PPSC) is responsible for creating and maintaining the EPCglobal Privacy Policy; readers should refer to PPSC documents for more information.

As the EPCglobal Privacy Policy evolves, it is anticipated that some elements of the Privacy Policy will rely on features of the EPCglobal Architecture Framework for their implementation. The UHF Class 1 Gen 2 Tag Protocol provides a 32-bit "Kill" code to facilitate rapid destruction of tags at point-of-sale or other points where ownership of a tagged item transitions to a member of the general public. Other architectural aspects are expected to emerge as the Privacy Policy evolves, and will be described in future versions of this document.

3.8 Industry Architectures and Standards

The EPCglobal Architecture Framework is designed to work with and complement existing industry-wide architectures and standards. For example, if the automotive or healthcare industry has registries, data exchanges, or data pools, it should be able to utilize and leverage the EPCglobal Network. The same holds true for Fast Moving Consumer Goods (FMCG) industries.

A specific example is the significant investment that FMCG companies have made in data synchronization, which will continue for the foreseeable future. Depending on the industry, participation in these and other enablers of e-commerce may be viewed as a prerequisite for or as complementary to use of the EPCglobal Network in its goals for improved supply chain operations.

3.9 Open, Community Process

The EPCglobal standards development process is designed to yield standards that are relevant and beneficial to end users. Important aspects of the process include:

- End user involvement in developing requirements through the Business Action Groups.
- Open process in which all EPCglobal subscribers having relevant expertise are encouraged to join working groups that create new standards.
- Several review milestones in which new standards are vetted by a wide community before final adoption.

4 Underlying Technical Principles

This section explains the design principles that underlie all parts of the EPCglobal Architecture Framework. Working Groups should take these principles into account as they develop new specifications.

4.1 Unique Identity

A fundamental principle of the EPCglobal Network Architecture is the assignment of a unique identity to physical objects, loads, locations, assets, and other entities whose use is to be tracked. By "unique identity" is simply meant a name, such that the name assigned to one entity is different than the name assigned to another entity. In the EPCglobal Network Architecture, the unique identity is the Electronic Product Code, defined by the EPCglobal Tag Data Specification [TDS1.1].

Unique identity within the EPCglobal Network Architecture, as embodied in the Electronic Product Code, has these characteristics:

- *Uniqueness*   The EPC assigned to one entity is different than the EPC assigned to another (but see below for exceptions).
- *Federation*   The EPC is not a single naming structure, but a federation of several naming structures. This allows existing naming structures to be incorporated into the EPC system, so that the EPC is a universal identifier. This attribute is extremely important to ensure wide adoption of the EPC, which would be significantly more difficult if adoption required adoption of a single naming structure.

  For example, both GS1 SSCC codes and GS1 GRAI codes [EANUCC] are also valid EPCs. The various concrete representations of the EPC use a system of headers (textual or binary according to the representation) to distinguish one identity scheme from another; when one EPC is compared to another, the header is always included so that EPCs drawn from different schemes will always be considered distinct. The header is always considered to be a part of the EPC, not something separate.

While the EPC is designed to federate multiple naming structures, there may be performance tradeoffs, especially with respect to RFID tag performance, when multiple naming structures are used in the same business context. For this reason, there is motivation to minimize the number of distinct naming structures used within any given industry.

- *Representation independence* EPCs are defined in terms of abstract structure, which has several concrete realizations. Especially important are the binary realization that is used on RFID tags and the Universal Resource Identifier (URI) realization that is used for data exchange. Formal conversion rules exist, and work is underway (within the Tag Data Translation Working Group) to create a machine-readable form of these rules.
- *Decentralized assignment* EPCs are designed so that independent organizations can assign new EPCs without the possibility of collision. This is done through a hierarchical scheme, not unlike the Internet Domain Name System though somewhat more structured. EPCglobal acts as the Registration Authority for the overall EPC namespace. Each naming structure that is federated within the EPC namespace has a space of codes managed by an Issuing Agency. For the EPC naming structures based on the GS1 family of codes (SGTIN, SSCC, etc), for example, GS1 is the Issuing Agency. An Issuing Agency allocates a portion of the EPC space to a subscriber organization, who then becomes the "EPC Manager" for that block of codes. For GS1 codes, for example, this is done by assigning a Company Prefix to a subscriber. The subscriber is then free to assign EPCs within its allocated portion without any further coordination with any outside agency. (Since there are several EPC naming structures based on GS1 codes, assigning a single Company Prefix has the effect of allocating several blocks of codes to a subscriber, one block within each GS1 coding scheme.)
- *Structure* EPCs are not purely random strings, but rather have a certain amount of internal structure in the form of designated fields. This plays a role in decentralization, as described above. More significantly, the EPC's internal structure is essential to the scalability of lookup services such as the Object Name Service which exploit the structure of EPCs to distribute lookup processing across a scalable network of services.
- *Light Weight* EPCs have just enough structure and information to accomplish the goals above, and no more. Other information associated with EPC-bearing entities is not encoded into the EPC itself, but rather associated with the EPC through other means.

While EPCs are intended to be globally unique in most situations, there are some varieties of EPCs that are not. In particular, a portion of EPC space may be derived from an existing coding scheme for which global uniqueness is not guaranteed. In that situation, the EPCs from that space have uniqueness guarantees which are no stronger than the original scheme. For example, GS1 SSCC codes are not unique over all time and space, but due to the limited size of the SSCC namespace they are recycled periodically. Good practice dictates that SSCCs be recycled no more frequently than the lifetime of loads within the supply chain to which the SSCCs are affixed (plus a reasonable data retention period). This eliminates the possibility that two identical SSCCs would be present on two different loads at the same time, but it might still be possible to find identical SSCCs for different loads in a long-term historical database. Applications that rely on uniqueness properties of EPCs must understand the properties of the various EPC namespaces that they might encounter, and act accordingly.

In other instances, what appears to be a single physical entity may have more than one identity, and therefore more than one EPC. A typical example is a palletized load that sits on a reusable pallet skid. In this example, there might be one EPC denoting the load, and another EPC denoting the reusable skid. (In the GS1 system, the load might be given an SSCC EPC, while the skid might be given a GRAI EPC.) During the lifetime of the palletized load these two EPCs appear to be associated with the same physical entity, but when the load is broken down the load EPC is decommissioned, while the pallet skid EPC continues to live as long as the pallet is reused. In this example, what appears to be one physical entity really consists of two separate entities from a business perspective (the pallet and the load), and so what appears to be multiple EPCs assigned to the same object is really a separate EPC for each entity.

Another instance where global uniqueness may not be required is when EPC technology is used for closed systems, such as proprietary use within a single company. In most cases, the cost of achieving global uniqueness (that is, in obtaining an EPCglobal Manager Number) is so low that doing so is recommended even for a closed system. Nevertheless, the Tag Data Standards Working Group is currently considering whether any special provision for closed systems should be made in a future version of the EPC Tag Data Standard.

4.2 Decentralized Implementation

The EPCglobal Network seeks to link all enterprises together in a single global network. Logically, the EPCglobal Network is a common resource shared by all EPCglobal Subscribers. Considerations of scalability, of course, imply that it is not feasible to literally implement this common resource as a single physical instance of a computer system operated by a central authority. The EPCglobal Architecture Framework is therefore decentralized, meaning that logically centralized functions are distributed among one or more facilities serving individual EPCglobal Subscribers. In some cases, certain of these facilities are operated by EPCglobal Subscribers themselves.

The key elements of decentralization in the EPCglobal Architecture Framework are the assignment of EPC codes, and the ONS lookup service. These elements of decentralization are discussed in more detail in Sections 5.2, 7.1, and 7.3 .

4.3 Layering of Data Standards – Verticalization

The EPCglobal Architecture Framework includes standards for data exchange that are intended to serve the needs of many different industries. Yet, each industry has specific requirements around what data needs to be exchanged and what it means.

Consequently, EPCglobal standards that govern data are designed in a layered fashion. Within each data standard, there is a framework layer that applies equally to all industries that use the EPCglobal Network. Layered on top of this are several vertical data standards that populate the general framework, each serving the needs of particular industry groups. Vertical data standards may be broad or narrow in their applicability: in many cases a vertical standard will serve several industries that share common business processes, while in other cases a vertical standard will be particular to one industry. It is even possible for a private group of trading partners to develop their own specifications atop the framework similar to a vertical standard. The framework layers tend to be developed by EPCglobal technical action groups, while the requirements for vertical standards tend to be developed by appropriate industry groups.

The two important data standards are the EPC Tag Data Specification, and the EPCIS Data Specification. Within the EPC Tag Data Specification, the framework elements include the structure of the "header bits" in the binary EPC representations and the general URI structure of of the text-based EPC representations. Both of these features serve to distinguish one coding scheme from another. The vertical layer of the EPC Tag Data Specification are the specific coding schemes defined for particular industry groups.

Within the EPCIS Data Specification, the framework elements include the abstract data model that lays out a general organization for master data and transactional event data. The vertical layers of the EPCIS Data Specification define specific event types, master data vocabularies, and master data attributes used within a particular industry.

4.4 Layering of Software Specifications—Technology Agnosticism

The EPCglobal Architecture Framework is primarily concerned with the exploitation of new data derived from the use of Electronic Product Codes and RFID technology within business processes. Most of the content of EPCglobal standards does not rely on specific implementation technology such as web services, XML, AS2, EDI, and so on. Each enterprise has its own requirements and preferences for underlying technologies such as these, and these inevitably change over time.

To foster the broadest possible applicability for EPCglobal standards, EPCglobal software standards are, whenever possible, defined using a layered approach. In this approach, the abstract content of data and/or services is defined using a technology-neutral description language such as UML. Separately, the abstract specifications are given one or more bindings to specific implementation technology such as XML, web services, and so forth. As most of the technical "meat" of EPCglobal specifications exists in the abstract content, this approach helps ensure that even when different implementation technologies are used in different deployments there is a strong commonality in what the systems do.

4.5 Extensibility

The EPCglobal Architecture Framework explicitly recognizes the fact that change is inevitable. A general design principle for all EPCglobal Standards is openness to extension. Extensions include both enhancements to the standards themselves, through the introduction of new versions of a standard, and extensions made by a particular enterprise, group of cooperating enterprises, or industry vertical, to address specific needs that are not appropriate to address in an EPCglobal specification.

All EPCglobal Standards have identified points where extensions may be made, and provide explicit mechanisms for doing so. As far as is practical, the extension mechanisms are designed to promote both backward compatibility (a newer or extended implementation should continue to interoperate with an older implementation) and forward compatibility (an older implementation should continue to interoperate with a newer or extended implementation, though it may not be able to exploit the new features). The extension mechanisms are also designed so that non-standard extensions may be made independently by multiple groups, without the possibility of conflict or collision.

Non-standard extensions are accommodated not only because they are necessary to meet specific requirements that individual enterprises, groups, or industry verticals may have, but also because it is an excellent way to experiment with new innovations that will ultimately become standardized through newer versions of EPCglobal Standards. The extension mechanisms are designed to provide a smooth path for this migration.

5 Architectural Foundations

This section describes the key design elements at the foundations of the EPCglobal Architecture Framework. This sets the stage for the detailed description of the framework given in Sections 6, 7, and 8.

5.1 Electronic Product Code

As previously described in Section 4.1, the Electronic Product Code is the embodiment of the underlying principle of unique identity. Electronic Product Codes are assigned to physical objects, loads, locations, assets, and other entities which are to be tracked through the EPCglobal Network in service of a given industry's business goals. The Electronic Product Code is the thread that ties together all data that flows within the EPCglobal Network, and plays a central part in every role and interface within the EPCglobal Architecture Framework.

5.2 EPC Manager

As noted in Section 4.1, a key characteristic of identity as used in the EPCglobal Architecture Framework is decentralization. Decentralization is achieved through the notion of an EPC Manager. Within this document, the term "EPC Manager" refers to an EPCglobal Subscriber who has been granted rights to use a portion of the EPC namespace by an Issuing Agency. That is, the Issuing Agency has effectively issued the EPC Manager one or more blocks of Electronic Product Codes within designated coding schemes that the EPC Manager can independently assign to physical objects and other entities without further involvement of the Issuing Agency. The EPC Manager is said to be the "managing authority" for the EPCs in this block.

The EPC Manager has two special responsibilities within the EPCglobal Architecture Framework that distinguish it from all other EPCglobal subscribers, with respect to the EPC codes it manages:

- The EPC Manager is responsible for allocating a new EPC from its assigned block, and associating it with a physical object or other entity. In so doing, the EPC Manager must ensure that the appropriate uniqueness properties are maintained (see Section 4.1). The act of allocating a new EPC is called "commissioning."
- The EPC Manager is responsible for maintaining the Object Name Service (ONS) records associated with blocks of EPCs it manages. ONS records are the point of entry for certain types of global lookup operations as described in later sections. (This responsibility is limited to those blocks of EPCs that are allocated by the EPC Manager for objects that are exchanged with other Subscribers; any EPC blocks reserved for internal use by the EPC Manager need not be reflected in ONS. Also, the EPC Manager may elect not to provide ONS lookup for any or all of its EPCs, in which case there is obviously no requirement to maintain ONS records for those EPCs.)

Other than these two responsibilities, the EPC Manager has no special responsibilities with respect to the EPCs it manages compared to any other EPCglobal Subscriber. In particular, both the EPC Manager and other subscribers participate equally in the generation and exchange of EPC-related data.

5.3 EPC Manager Number

The way that an Issuing Agency grants a block of EPCs to an EPC Manager is by issuing the EPC Manager a single number, called the EPC Manager Number. An End-User Subscriber may hold multiple Manager Numbers, and therefore be in control of multiple blocks of EPCs. The structure of all coding schemes within the Electronic Product Code definition is such that the EPC Manager Number appears as a distinct field within any given representation.

Having the EPC Manager Number as a distinct field within any given representation, allows any system to instantly identify the EPC Manager associated with a given EPC. This property is very important to insure the scalability of the overall system, as it allows services that would otherwise be centralized to be delegated to each EPC Manager as appropriate. For example, an ONS lookup is conceptually a lookup in a single large table that maps any EPC to the location of an EPCIS service, but having the EPC Manager Number as a distinct field allows ONS to be implemented as a collection of tables, each maintained by the EPC Manager for a given block of EPCs (see Section 7.3 for more information on ONS specifically).

The allocation of a block of EPC codes to an EPC Manager is actually implicit in the act of assigning an EPC Manager Number. The EPC Manager is simply free to commission any EPC code so long as the EPC Manager Number field within the code contains the assigned EPC Manager Number, following the EPC Tag Data Specification. The "block" of codes, therefore, simply consists of all EPCs that contain the assigned EPC Manager Number in the EPC Manager Number field. (This a slight simplification; see Section 5.4 for more information.)

5.4 Embedding of Existing Codes

Most coding schemes currently defined with the EPC Tag Data Specification are based on existing industry coding schemes. For example, there are five types of EPCs based on the GS1 family of codes: SGTIN, SSCC, SGLN, GRAI, and GIAI. In the case of these GS1 codes, the EPC Manager Number is one and the same as the GS1 Company Prefix that forms the basis of the GS1 codes. The other fields of GS1-based EPCs are also derived from existing fields of the GS1 codes.

In general, this kind of embedding is possible for any existing coding scheme that has a manager-like structure; that is, when the existing coding scheme is based on delegating assignment through the central allocation of a unique prefix or field. The US Department of Defense, for example, has defined an EPC coding scheme based on its own CAGE and DoDAAC codes, which are issued uniquely to DoD suppliers and thus serve as EPC Manager Numbers when used to construct EPCs using the "DoD construct" coding scheme.

In the last section, it was noted that assigning an EPC Manager Number to an EPC Manager effectively allocates a block of codes to the EPC Manager. Because the Electronic Product Code federates several coding schemes, the "block" of EPC codes implied by the assignment of an EPC Manager Number is not necessarily a single contiguous block of numbers, but rather a contiguous block within each EPC identity type to which the EPC Manager Number pertains. For example, when an EPC Manager Number is a GS1 Company Prefix, the EPC Manager is effectively granted a block of EPCs within each of the five GS1-related EPC types (SGTIN, SSCC, SGLN, GRAI, and GIAI). But when an EPC Manager Number is a US Department of Defense CAGE/DoDAAC code, the EPC Manager is effectively granted a single block of EPCs, within the "DoD Construct" coding scheme.

5.5 Class Level Data versus Instance Level Data

EPCs are assigned uniquely to physical objects and other entities, allowing data to be associated with individual objects. For example, one can associate data with a specific 24-count case of Cherry Hydro Soda by referring to its unique EPC.

In some cases, it is necessary to associate data with a class of object rather than a specific object itself. In the case of consumer goods, an object class refers to all instances of a specific product (Stock Keeping Unit, or SKU); for example, the class representing all 24-count cases of Cherry Hydro Soda. For Electronic Product Codes having a three-part structure of EPC Manager Number, Object Class ID, and Serial Number, a product class is uniquely identified by the first two numbers, disregarding the Serial Number. The Serialized Global Trade Item Number (SGTIN) coding scheme used in the consumer packaged goods industry is an example of an EPC having this structure. In this particular example, the EPC Manager Number and Object Class ID are in fact convertible to the GTIN code that is used outside of the EPC arena to represent product classes. This is another example of how existing codes are embedded within the Electronic Product Code framework.

Some kinds of Electronic Product Codes are used to identify things that do not have any meaningful grouping into object classes. For example, the Serialized Shipping Container Code is a type of EPC used to identify shipping loads, where each load may contain a unique assortment of products. Codes of this kind often have a two-part structure, as the SSCC does, consisting only of an EPC Manager Number and a Serial Number.

5.6 EPC Information Services (EPCIS)

The primary vehicle for data exchange between EPCglobal Subscribers in the EPCglobal Architecture Framework is EPC Information Services (EPCIS). As explained below, EPCIS encompasses both interfaces for data exchange and specifications of the data itself.

EPCIS data is information that trading partners share to gain more insight into what is happening to physical objects in locations not under their direct control. (EPCIS data may, of course, also be used within a company's four walls.) For most industries using the EPCglobal Network, EPCIS data can be divided into five categories, as follows:

- *Static Data*, which does not change over the life of a physical object. This includes:
  - *Class-level Static Data*; that is, data which is the same for all objects of a given object class (see Section 0). For consumer products, for example, the "class" is the product, or SKU, as opposed to distinct instances of a given product. In many industries, class-level static data may be the subject of existing data synchronization mechanisms such as the Global Data Synchronization Network (GDSN); in such instances, EPCIS may not be the primary means of exchange.
  - *Instance-level Static Data*, which may differ from one instance to the next within a given object class. Examples of instance-level static data include such things as date of manufacture, lot number, expiration date, and so forth. Instance-level static data generally takes the form of attributes associated with specific EPCs.
- *Transactional Data*, which does grow and change over the life of a physical object. This includes:
  - *Instance Observations*, which record events that occur in the life of one or more specific EPCs. Examples of instance observations include "EPC X was shipped at 12:03pm 15 March 2004 from Acme Distribution Center #2," and "At 3:45pm 22 Jan 2005 the case EPCs (list here) were aggregated to the pallet EPC X at ABC Corp's Boston factory." Most instance observations have four dimensions: time, location, one or more EPCs, and business process step.
  - *Quantity Observations*, which record events concerned with measuring the quantity of objects within a particular object class. An example of a quantity observation is "There were 4,100 instances of object class C observed at 2:00am

16 Jan 2003 in RetailMart Store #23." Most quantity observations have five dimensions: time, location, object class, quantity, and business process step.

- *Business Transaction Observations*, which record an association between one or more EPCs and a business transaction. An example of a business transaction observation is "The pallet with EPC X was shipped in fulfillment of Acme Corp purchase order #23 at 2:20pm." Most business transaction observations have four dimensions: time, one or more EPCs, a business process step, and a business transaction identifier.

The EPCIS Data Specifications provide a precise definition of all the types of EPCIS data, as well as the meaning of "event" as used above.

Transactional data differs from static data not only because as it grows and changes over the life of a physical object, but also because transactional data for a given EPC is typically generated by many distinct enterprises within a supply chain. For example, consider an object that is manufactured by A, who employs transportation company B to ship to distributor C, who delivers the object by way of 3rd party logistics provider D to retailer E. By the time the object reaches E, all five companies will have gathered transactional data about the EPC. The static data, in contrast, often comes exclusively from the manufacturer A.

A key challenge faced by the EPCglobal Network is to allow any participant in the supply chain to discover all transactional data to which it is authorized, from any other participant. Section 7.1 discusses how the EPCglobal Architecture Framework addresses this challenge.

6 Roles and Interfaces – General Considerations

This section and the three sections that follow define the EPCglobal Architecture Framework, describing at a high level all of the EPCglobal Standards and EPCglobal Core Services that comprise it. The normative description of each of these is found elsewhere. In the case of an EPCglobal Standard, the normative description is or will be an EPCglobal specification document. In the case of an EPCglobal Core Service, normative descriptions are either provided as EPCglobal Standards (for interface aspects of Core Services) or in other EPCglobal documentation (for implementation aspects of Core Services).

As noted in Section 2, a specific EPCglobal Standard is either ratified, in development within an EPCglobal technical Working Group, or TBD meaning that requirements are still under discussion within EPCglobal Business Action Groups or the Architecture Review Committee. Where ratified specifications exist, this document provides citations to the specification document, which provides the normative description. Otherwise, details beyond what is described herein are only available to EPCglobal Subscribers who have joined the appropriate EPCglobal Working Group or Action Group.

6.1 Architecture Framework vs. System Architecture

The EPCglobal Architecture Framework is a collection of interrelated standards for hardware, software, and data interfaces (EPCglobal Standards), together with core services that are operated by EPCglobal and its delegates (EPCglobal Core Services). End users deploy systems that make use of these elements of the EPCglobal Architecture Framework. In particular, each end user will have a system architecture for their deployment that includes various hardware and software components, and these components may use EPCglobal Standards to communicate with each other and with external systems, and also make use of the EPCglobal Core Services to carry out certain tasks.

The EPCglobal Architecture Framework does not define a system architecture that end users must implement, nor does it dictate particular hardware or software components an end user must deploy. The hardware and software components within any end user's system architecture may be created by the end user or obtained by the end user from vendors, but in any case the definition of these components is outside the scope of the EPCglobal Architecture Framework. The EPCglobal Architecture Framework only defines interfaces that the end user's components may implement. The EPCglobal Architecture Framework explicitly avoids specification of components in order to give end users maximal freedom in designing system architectures according to their own preferences and goals, while defining interface standards to ensure that systems deployed by different end users can interoperate and that end users have a wide marketplace of vendor-provided components from which to choose.

Because the EPCglobal Architecture Framework does not define a system architecture *per se*, this document does not normatively specify a particular arrangement of system components and their interconnection. However, in order to understand the interrelationship of EPCglobal Standards and Core Services, it is helpful to discuss how they are used in a typical system architecture. The following sections of this document, therefore, describe a hypothetical system architecture to illustrate how the components of the EPCglobal Architecture Framework fit together. It is important to bear in mind, however, that the following description differs from a true system architecture in the following ways:

- An end-user system architecture may only need to employ a subset of the EPCglobal Standards and Core Services depicted here. For example, an RFID application using EPC tags that exists entirely within the four walls of a single enterprise may use the UHF Class 1 Gen 2 Tag Protocol and the EPC Tag Data Standards, but have no need for the Object Name Service.

- The mapping between hardware and software roles depicted here and actual hardware or software components deployed by an end-user may not necessarily be one-to-one. For example, to carry out a business process of shipment verification using EPC-encoded RFID tags, one end user may deploy a system in which there is a separate RFID Reader (a hardware device), Filtering & Collection Middleware (software deployed on a server), and EPCIS Capturing Application (software deployed on a different server). Another end user may deploy an integrated verification portal device that combines into a single package all three of these roles, exposing only the

EPCIS Capture Interface. For this reason, this document is careful to refer to *roles* rather than *components* when talking about system elements that make use of standard interfaces.

- In the same vein, roles depicted here may be carried out by an end user's legacy system components that may have additional responsibilities outside the scope of the EPCglobal Architecture Framework. For example, it is common to have enterprise applications such as Warehouse Management Systems that simultaneously play the role of EPCIS Capturing Application (e.g., detecting EPCs during product movement during truck loading), an EPCIS-enabled Repository (e.g., recording case-to-pallet associations), and an EPCIS Accessing Application (e.g., carrying out business decisions based on EPCIS-level data).

The overall intent of the EPCglobal Architecture Framework is to provide end users with great flexibility in creating system architectures that meet their needs.

6.2 Cross-Enterprise versus Intra-Enterprise

As discussed in Section 2, elements of the EPCglobal Architecture Framework can be categorized as pertaining to EPC Data Exchange between enterprises, EPC Object Exchange between enterprises, or EPC Infrastructure deployed within a single enterprise. Clearly, all EPCglobal Subscribers will find relevance in the first two categories, as use of these standards is necessary to interact with other subscribers. A subscriber has much more latitude, however, in its decisions surrounding adoption of the EPC Infrastructure standards, as those standards do not affect parties outside the subscriber's own four walls.

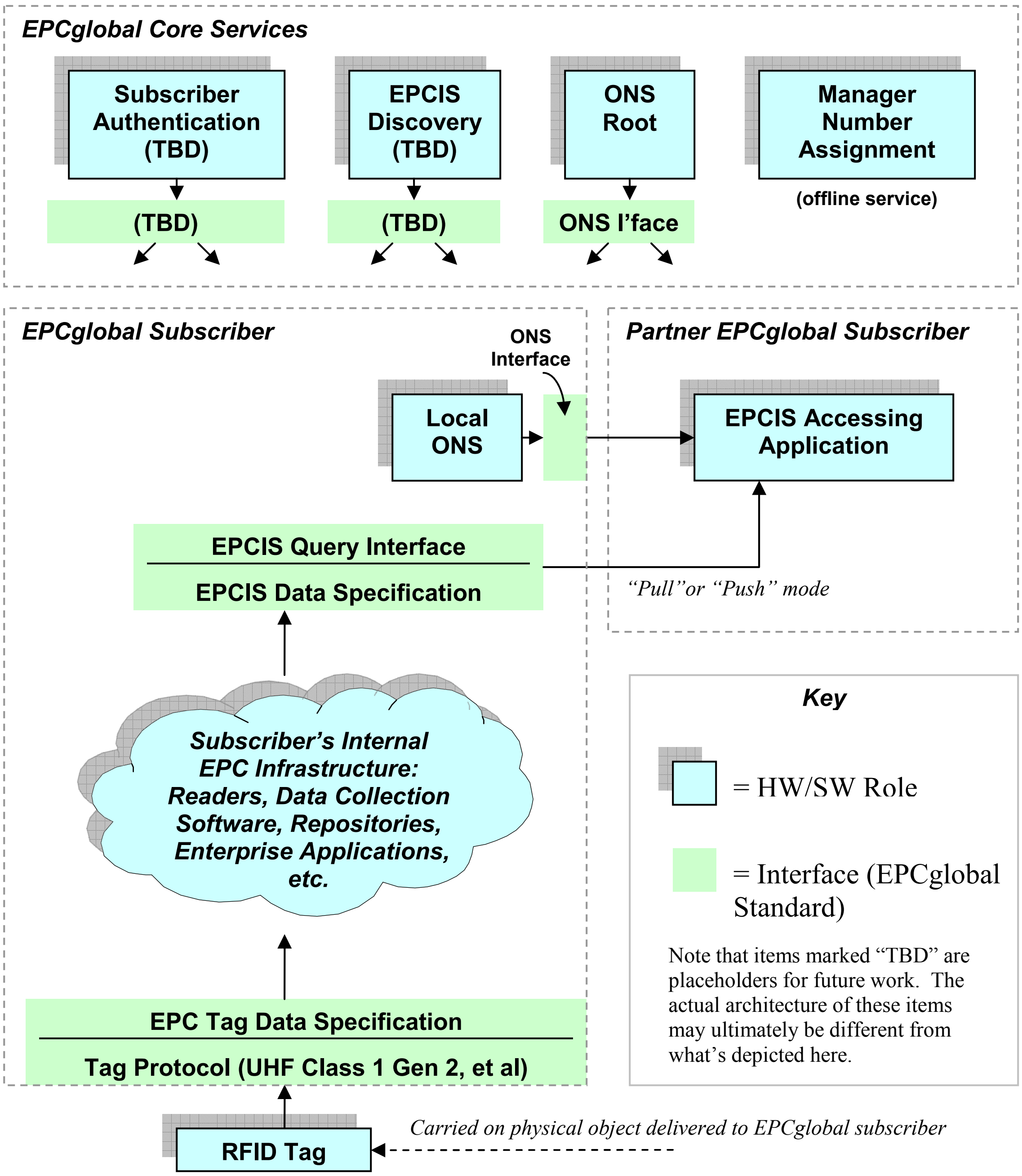
For this reason, the following discussion of roles and interfaces within the EPCglobal Architecture Framework is divided into two sections, the first dealing with cross-enterprise elements (EPC Data Exchange and EPC Object Exchange), and the second dealing with intra-enterprise elements (EPC Infrastructure). As explained in Section 2, however, it should be borne in mind that the division between cross-enterprise and intra-enterprise standards is not absolute, and a given enterprise may employ cross-enterprise standards entirely within its four walls or conversely use intra-enterprise standards in collaboration with outside parties.

7 Data Flow Relationships – Cross-Enterprise

This section provides a diagram showing the relationships between EPCglobal Standards, from a data flow perspective. This section shows only the EPCglobal Standards that are typically used between subscribers, namely those categorized as "EPC Object Exchange Standards" or "EPC Data Exchange Standards" in Section 2. EPCglobal Standards that are primarily used within the four walls of a single subscriber ("EPC Infrastructure Standards" from Section 2) are described in Section 8. Most EPCglobal Subscribers will implement the architecture given in this section in order to fully participate in the EPCglobal Network.

In the following diagram, the plain green bars denote interfaces governed by EPCglobal standards, while the blue "shadowed" boxes denote roles played by hardware and software components of a typical system architecture. As emphasized in Section 6.1, in any given end user's deployment the mapping of roles in this diagram to actual hardware and software components may not be one-to-one, nor will every end user's deployment contain every role shown here.

To emphasize how EPCglobal Standards are employed to share data between partners, this diagram shows one subscriber (labeled "EPCglobal Subscriber" in the diagram) who observes a physical object having an EPC on an RFID tag, and shares data about that observation with a second subscriber (labeled "Partner EPCglobal Subscriber"). This interaction is shown as one way, for clarity. In many situations, the Partner EPCglobal Subscriber may also be observing physical objects and sharing that data with the first EPCglobal Subscriber. If that is the case, then the full picture would show a mirror-image set of roles, interfaces, and interactions.



A formal definition of each of the roles and interfaces in this diagram may be found in Section 9. The remainder of this section provides a more informal illustration of how the roles and interfaces interact in typical scenarios of using the EPCglobal Network.

7.1 Data Exchange Interactions

The top part of the diagram shows the roles and interfaces involved in data exchange. The Partner EPCglobal Subscriber has an "EPCIS Accessing Application" (role), which is some application specific to the Partner EPCglobal Subscriber that is interested in information about a particular EPC.

The first thing the EPCIS Accessing Application needs to do is to determine where it can go to obtain data of interest. In general, there are several ways it may do so:

- The EPCIS Accessing Application may know in advance exactly where to find the information. This often arises in simple two-party supply chain scenarios, where one party is given the network address of the other party's EPCIS service as part of a business agreement.
- The EPCIS Accessing Application may know where to find the information it seeks based on information obtained previously. For example, in a three-party supply chain consisting of parties A, B, and C, party C may know how to reach B's service as part of a business agreement, and in obtaining information from B it learns how to reach A's service (which B knows as part of its business agreement with A). This is sometimes referred to as "following the chain."
- The EPCIS Accessing Application may use the Object Name Service (ONS) to locate the EPCIS service of the EPCglobal Subscriber who is the EPC Manager of the object in question.
- The EPCIS Accessing Application may use EPCIS Discovery Services to locate the EPCIS services of all EPCglobal Subscribers that have information about the object in question, including EPCglobal Subscribers other than the EPC Manager of the object. This method is required in the general case of multi-party supply chain, when the participants are not known to the EPCIS Accessing Application in advance and when it is not possible or impractical to "follow the chain." (EPCIS Discovery Services are TBD at the time of this writing, so the precise architecture of roles and interfaces involved in EPCIS Discovery Services is not yet known – the box in the diagram is just a placeholder.)

Whatever method is used, the net result is that the EPCIS Accessing Application has located the EPCIS service of the EPCglobal Subscriber from whom it will obtain data to which the EPCIS Accessing Application is authorized. The EPCIS Accessing Application then requests information directly from the EPCIS service of the other subscriber. Two EPCglobal Standards govern this interaction. The EPCIS Query Interface defines how data is requested and delivered from an EPCIS service. The EPCIS Data Specification define the format and meaning of this data. The EPCIS Query Interface is designed to support both on-demand or "pull" modes of data transfer, as well as asynchronous or "push" modes. Several transport bindings are provided, including on-line transport as well as disconnected (store and forward) transport.

When an EPCIS Accessing Application of the Partner EPCglobal Subscriber accesses the EPCIS service of the first EPCglobal Subscriber, the first EPCglobal Subscriber will usually want to authenticate the identity of the Partner EPCglobal Subscriber in order to determine what data the latter is authorized to receive. The Subscriber Authentication role in the diagram refers to an EPCglobal Core Service that assists in this authentication, making it possible for any EPCglobal Subscriber to authenticate the identity of any other EPCglobal Subscriber without any prior arrangement between the two parties.

(Subscriber Authentication is TBD at the time of this writing, so the precise architecture of roles and interfaces involved in Subscriber Authentication is not yet known – the box in the diagram is just a placeholder.) In some situations, an EPCglobal Subscriber may grant EPCIS access to another party whose identity is not authenticated or authenticated by means other than those facilitated by EPCglobal. This is a policy decision that is up to each EPCglobal Subscriber to make.

7.2 Object Exchange Interactions

The lower part of the diagram illustrates how the first EPCglobal Subscriber interacts with physical objects it receives from other subscribers. A physical object is received by the EPCglobal Subscriber, bearing an RFID tag that contains an EPC code. The EPCglobal Subscriber reads the tag using RFID Readers deployed as part of its internal EPC infrastructure. Two EPCglobal Standards govern this interaction. A tag protocol defines how data is carried through a radio signal to the RFID Reader. The EPC Tag Data Specification defines the format and meaning of this data, namely the EPC code.

Within the EPCglobal Subscriber's internal EPC infrastructure, there may be many hardware and software components involved in obtaining and processing the tag read, integrating the tag read into an ongoing business process, and ultimately using the tag read to help in creating an EPCIS event that can be made available to a Partner EPCglobal Subscriber via EPCIS as previously described. A single tag read could in theory result in a new EPCIS event by itself; far more commonly, each EPCIS event results from many tag reads together with other information derived from the business context in which the tag (or tags) were read. Some scenarios of how this takes place are illustrated in Section 8.

7.3 ONS Interactions

In Section 7.1, it was mentioned that one EPCglobal Subscriber may locate the EPCIS service of the EPC Manager associated with a given EPC by using the Object Name Service, or ONS. This section describes in somewhat more detail how this takes place as a collaboration between an EPCglobal Core Service and a service provided by an individual subscriber.

The Object Name Service can be thought of as a simple lookup service that takes an EPC as input, and produces as output the address (in the form of a Uniform Resource Locator, or URL) of an EPCIS service designated by the EPC Manager of the EPC in question. (An EPC Manager may actually use ONS to associate several different services, not just an EPCIS service, with an EPC. All of the following discussion applies equally regardless of which type of service is looked up.) In general, there may be many different object classes that fall under the authority of a single EPC Manager, and it may not be the case that all object classes of a given EPC Manager will have information provided by the same EPCIS service. Therefore, ONS requires a separate entry for each object class. (The current design of ONS does not, however, permit different entries for different serial numbers of the *same* object class. The current ONS specification also does not address coding schemes which do not have a field corresponding to object class, such as the SSCC and GIAI codes.)

Conceptually, this is a single global lookup service. It would not be practical, however, to implement ONS as one gigantic directory, both for reasons of scalability and in consideration of the difficulty of each EPC Manager organization having to maintain records for its object classes in a shared database. Instead, ONS is architected as an application of the Internet Domain Name Service (DNS), which is also a single global lookup service conceptually but is implemented as a hierarchy of lookup services.

ONS works as follows. When an EPCglobal Subscriber wishes to locate an EPCIS service, it first consults the Root ONS service controlled by EPCglobal. The Root ONS service identifies the Local ONS service of the EPC Manager organization for that EPC. The EPCglobal Subscriber then completes the lookup by consulting the Local ONS service, which provides the pointer to the EPCIS service in question.

ONS is implemented as an application of DNS, simply by specifying a convention whereby an EPC is converted to an Internet Domain Name in the `onsepc.com` domain. This has several implications:

- The "Root ONS service" and "Local ONS service" as used above may each be implemented by multiple independent servers, as DNS allows more than one server to be listed as the provider of DNS service for any particular domain name. This increases the scalability and reliability of the overall system.
- EPCglobal's Root ONS service is actually itself two levels down in a hierarchy of lookups, which has its true root in the worldwide DNS root service.
- ONS benefits from the DNS caching mechanism, which means that in practice a given ONS lookup does not actually need to consult each of the services in the hierarchy, as in most cases the higher-level entries are cached locally.

More information may be found in the DNS specifications [RFC1034, RFC1035], and in the ONS Specification [ONS1.0].

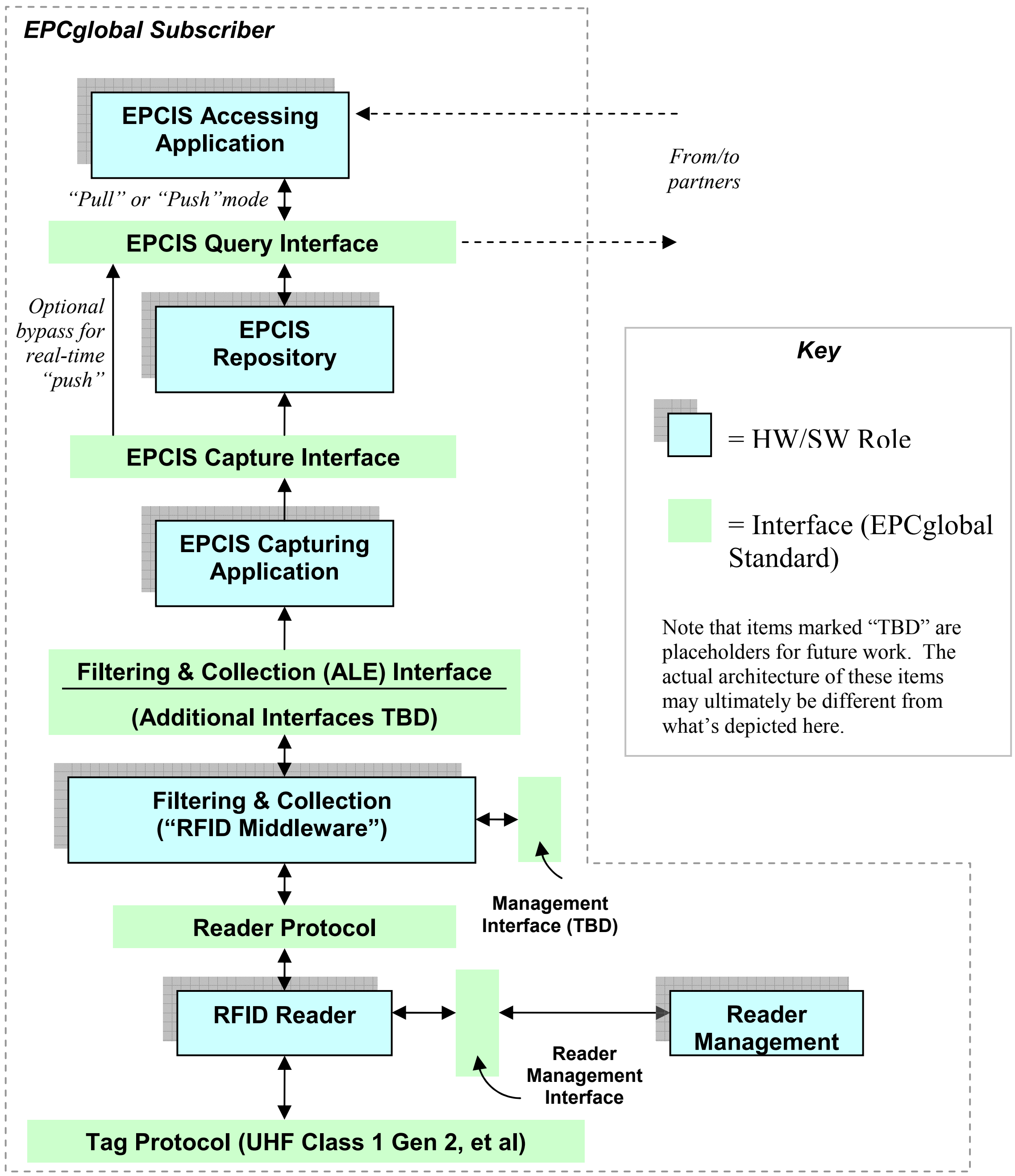
7.4 Number Assignment

The foregoing text has described every role and interface in the diagram at the beginning of this Section 7, except for Manager Number Assignment. This role simply refers to EPCglobal's service of issuing unique EPC Manager Numbers to each EPC Manager organization that requests one, in its capacity as the Issuing Agency for the GS1 family of codes (see Section 4.1). By insuring that every EPC Manager Number that is issued is unique, the uniqueness of EPCs assigned by individual EPCglobal Subscribers within the GS1 family of codes is ensured. (Number assignment for other coding schemes is carried out by Issuing Agencies other than EPCglobal, and so EPCglobal's Manager Number Assignment Core Service does not apply in those cases.)

8 Data Flow Relationships – Intra-Enterprise

This section provides a diagram showing the relationships between EPCglobal Standards, from a data flow perspective. In contrast to Section 7, this section shows only the EPCglobal Standards that are typically used within the four walls of a single subscriber, namely those categorized as "EPC Infrastructure Standards" in Section 2. This section expands the “cloud” in the diagram from Section 7. Because this cloud is completely internal to a given enterprise, a subscriber has much more latitude to deviate from this picture when appropriate to that subscriber’s unique business conditions. EPCglobal sets standards in this area, however, to encourage solution providers to create interoperable system components from which subscribers may choose.

As in Section 7, the plain green bars in the diagram below denote interfaces governed by EPCglobal standards, while the blue “shadowed” boxes denote roles played by hardware and software components of a typical system architecture. As emphasized in Section 6.1, in any given end user’s deployment the mapping of roles in this diagram to actual hardware and software components may not be one-to-one, nor will every end user’s deployment contain every role shown here.



Between the EPC Object Exchange interfaces and the EPC Data Exchange interfaces in the figure from Section 7 is a "cloud" of internal infrastructure whose purpose is to create EPCIS-level data from RFID observations of EPCs and other data sources. The figure above shows a typical approach to architecting this infrastructure, showing the role that EPCglobal standards play.

Several steps are shown in the figure, each mediated by an EPCglobal standard interface. At each step progressing from raw tag reads at the bottom to EPCIS data at the top, the semantic content of the data is enriched. Following the data flow from the bottom of the figure to the top:

- *Readers* Make multiple observations of RFID tags while they are in the read zone.
- *Reader Protocol Interface* Defines the control and delivery of raw tag reads from Readers to the Filtering & Collection role. Events at this interface say "Reader A saw EPC X at time T."
- *Filtering & Collection* This role filters and collects raw tag reads, over time intervals delimited by events defined by the EPCIS Capturing Application (e.g. tripping a motion detector).
- *Filtering & Collection (ALE) Interface* Defines the control and delivery of filtered and collected tag read data from Filtering & Collection role to the EPCIS Capturing Application role. Events at this interface say "At Location L, between time T1 and T2, the following EPCs were observed," where the list of EPCs has no duplicates and has been filtered by criteria defined by the EPCIS Capturing Application.
- *EPCIS Capturing Application* Supervises the operation of the lower EPC elements, and provides business context by coordinating with other sources of information involved in executing a particular step of a business process. The EPCIS Capturing Application may, for example, coordinate a conveyor system with Filtering & Collection events, may check for exceptional conditions and take corrective action (e.g., diverting a bad case into a rework area), may present information to a human operator, and so on. The EPCIS Capturing Application understands the business process step or steps during which EPCIS data capture takes place. This role may be complex, involving the association of multiple Filtering & Collection events with one or more business events, as in the loading of a shipment. Or it may be straightforward, as in an inventory business process where there may be "smart shelves" deployed that generate periodic observations about objects that enter or leave the shelf. Here, the Filtering & Collection-level event and the EPCIS-level event may be so similar that no actual processing at the EPCIS Capturing Application level is necessary, and the EPCIS Capturing Application merely configures and routes events from the Filtering & Collection interface directly to an EPCIS-enabled Repository.
- *EPCIS Capture Interface* The interface through which EPCIS data is delivered to enterprise-level roles, including EPCIS Repositories, EPCIS Accessing Applications, and data exchange with partners. Events at this interface say, for example, "At location X, at time T, the following contained objects (cases) were verified as being aggregated to the following containing object (pallet)."
- *EPCIS Accessing Application* Responsible for carrying out overall enterprise business processes, such as warehouse management, shipping and receiving, historical throughput analysis, and so forth, aided by EPC-related data.
- *EPCIS Repository* Software that records EPCIS-level events generated by one or more EPCIS Capturing Applications, and makes them available for later query by EPCIS Accessing Applications.

The interfaces within this stack are designed to insulate the higher levels of the stack from unnecessary details of how the lower levels are implemented. One way to understand this is to consider what happens if certain changes are made:

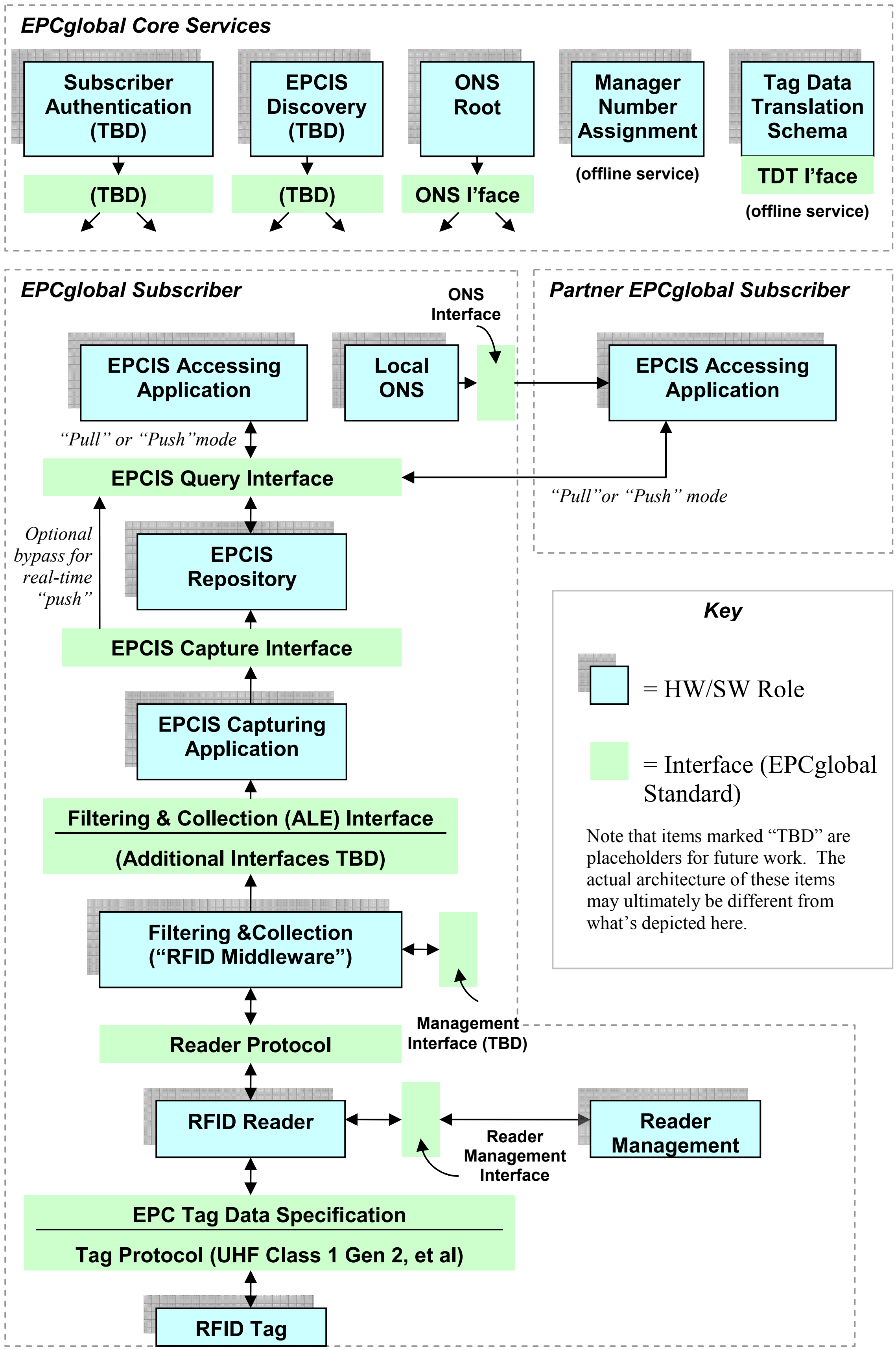
- The Reader Protocol Interface insulates the higher layers from knowing what reader makes/models have been chosen. If a different reader is substituted, the information at the Reader Protocol Interface remains the same. The Reader Protocol Interface may, to some extent, also provide insulation from knowing what tag protocols are in use, though obviously not when one tag type or tag protocol provides fundamentally different functionality from another.
- The Filtering & Collection Interface insulates the higher layers from the physical design choices made regarding how tags are sensed and accumulated, and how the time boundaries of events are triggered. If a single four-antenna reader is replaced by a constellation of five single-antenna "smart antenna" readers, the events at the Filtering & Collection level remain the same. Likewise, if a different triggering mechanism is used to mark the start and end of the time interval over which reads are accumulated, the Filtering & Collection event remains the same.
- The EPCIS interfaces insulate enterprise applications from understanding the details of how individual steps in a business process are carried out at a detailed level. For example, a typical EPCIS event is "At location X, at time T, the following cases were verified as being on the following pallet." In a conveyor-based business implementation, this likely corresponds to a single Filtering & Collection event, in which reads are accumulated during a time interval whose start and end is triggered by the case crossing electric eyes surrounding a reader mounted on the conveyor. But another implementation could involve three strong people who move around the cases and use hand-held readers to read the EPC codes. At the Filtering & Collection level, this looks very different (each triggering of the hand-held reader is likely a distinct Filtering & Collection event), and the processing done by the EPCIS Capturing Application is quite different (perhaps involving an interactive console that the people use to verify their work). But the EPCIS event is still the same.

In summary, the different steps in the data path correspond to different semantic levels, and serve to insulate different concerns from one another as data moves up from raw tag reads towards EPCIS.

Besides the data path described above, there is also a control path responsible for managing and monitoring of the infrastructure. At present, the only EPCglobal standard involved is the Reader Management standard.

9 Roles and Interfaces – Reference

This section provides a complete reference to all roles and interfaces described in Sections 7 and 8, describing each in more formal terms. For convenience, the following diagram combines the figures from the two previous sections into a single figure. As in Sections 7 and 8, the plain green bars in the diagram below denote interfaces governed by EPCglobal standards, while the blue "shadowed" boxes denote roles played by hardware and software components of a typical system architecture. As emphasized in Section 6.1, in any given end user's deployment the mapping of roles in this diagram to actual hardware and software components may not be one-to-one, nor will every end user's deployment contain every role shown here.


EPCglobal Core Services
Subscriber Authentication (TBD)
EPCIS Discovery (TBD)
ONS Root
Manager Number Assignment
Tag Data Translation Schema
(TBD)
(TBD)
ONS I'face
(offline service)
TDT I'face
(offline service)
EPCglobal Subscriber
ONS Interface
Partner EPCglobal Subscriber
EPCIS Accessing Application
Local ONS
EPCIS Accessing Application
"Pull" or "Push"mode
EPCIS Query Interface
"Pull"or "Push" mode
Optional bypass for real-time "push"
EPCIS Repository
EPCIS Capture Interface
Key
= HW/SW Role
= Interface (EPCglobal Standard)
Note that items marked "TBD" are placeholders for future work. The actual architecture of these items may ultimately be different from what's depicted here.
EPCIS Capturing Application
Filtering & Collection (ALE) Interface
(Additional Interfaces TBD)
Filtering &Collection ("RFID Middleware")
Management Interface (TBD)
Reader Protocol
RFID Reader
Reader Management
Reader Management Interface
EPC Tag Data Specification
Tag Protocol (UHF Class 1 Gen 2, et al)
RFID Tag

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The next section explains the roles and interfaces in this diagram in more detail.

9.1 Roles and Interfaces – Responsibilities and Collaborations

This section defines each of the roles and interfaces shown in the diagram above.

9.1.1 RFID Tag (Role)

Responsibilities:

- Holds an EPC code
- May allow the EPC code to be changed post-manufacture.
- May hold an immutable code that gives manufacture information, including the manufacturer identity, unique manufacture serial number, etc.
- May have additional user data apart from the EPC code.
- May have additional features such as lock, kill, access control, etc. These features may involve additional data stored on the tag such as a lock code, lock status, kill code, access password, etc.

9.1.2 EPC Tag Data Specification (Interface)

Normative references:

- Ratified EPCglobal Standard: [TDS1.0]

Responsibilities:

- Defines the overall structure of the Electronic Product Code, including the mechanism for federating different coding schemes.
- Defines specific EPCglobal coding schemes.
- For each EPCglobal coding scheme, defines binary representations for use on RFID tags, text representations for use within information systems (in particular, at the ALE level and higher in the EPCglobal Architecture Framework), and rules for converting between one representation and another.

9.1.3 Tag Protocol (Interface)

As explained in the notes to the table in Section 2, there are several Tag Protocols that have been defined for use within the EPCglobal Network: one that is a ratified EPCglobal standard (the UHF Class 1 Gen 2 tag protocol), and three others that were published by the Auto-ID Center prior to the creation of EPCglobal. The notes to the table in Section 2 give a full description of the status of each of these tag protocols. At the level of this document, the various tag protocols are essentially equivalent; they differ primarily in technical detail as to how commands and data are exchanged between reader and tag and what the specific command set is.

Normative references:

- EPCglobal Specifications (from Auto-ID Center): [UHFC0], [UHFC1G1], [HFC1]
- Ratified EPCglobal Standard: [UHFC1G2]

Responsibilities:

- Communicates a command to a tag from an RFID Reader.
- Communicates a response from a tag to the RFID Reader that issued the command.
- Provides means for a reader to singulate individual tags when more than one is within range of the RFID Reader.
- Provides means for readers and tags to minimize interference with each other.

9.1.4 RFID Reader (Role)

Responsibilities:

- Reads the EPCs of RFID Tags within range of one or more antennas (via a Tag Protocol) and reports the EPCs to a host application (via the Reader Protocol).
- When an RFID Tag allows the EPC code to be written post-manufacture, writes the EPC to a tag (via a Tag Protocol) as commanded by a host application (via the Reader Protocol).
- When an RFID Tag provides additional user data apart from the EPC code, reads and writes user data (via a Tag Protocol) as directed by a host application (via the Reader Protocol).
- When an RFID Tag provides additional features such as kill, lock, etc, operates those features (via a Tag Protocol) as directed by a host application (via the Reader Protocol).
- May provide additional processing such as filtering of EPCs, aggregation of reads, and so forth. See also the Filtering & Collection Role, Section 9.1.8.

9.1.5 Reader Protocol (Interface)

The Reader Protocol provides the means for software to control all aspects of RFID Reader operation, including all capabilities implied by features of the Tag Protocols. In particular, the EPCglobal Reader Protocol is intended to provide complete access to all capabilities of the UHF Class 1 Gen 2 Tag Protocol including modulation formats, data rates sessions, and passwords, as well as reading, writing, locking, and killing tags. As of this writing, the latest working draft of the Reader Protocol specification does not fully realize this goal, but it is the intent of EPCglobal to address this issue in a timely fashion.

Normative references:

- EPCglobal Working Draft: [RP1.0]

Responsibilities[1]*:*

- Provides means to command an RFID Reader to inventory tags (that is, to read the EPC codes carried on tags), read tags (that is, to read other data on the tags apart from the EPC code), write tags, manipulate tag user and tag-identification data, and access other features such as kill, lock, etc.
- May provide means to access RFID Reader management functions including discovery, firmware/software configuration and updates, health monitoring, connectivity monitoring, statistics gathering, antenna connectivity, transmit power level, and managing reader power consumption.
- May provide means to control RF aspects of RFID Reader operation including control of RF spectrum utilization, interference detection and measurement, modulation format, data rates, etc.
- May provide means to control aspects of Tag Protocol operation, including protocol parameters and singulation parameters.
- May provide access to processing features such as filtering of EPCs, aggregation of reads, and so forth. For features that require converting between different representations of EPCs, may use the Tag Data Translation Interface (Section 9.1.20) to obtain machine-readable rules for doing so.

Some of the responsibilities enumerated above are not yet addressed in the latest working draft of the Reader Protocol specification, but will be addressed as the specification evolves to fully exploit features of the UHF Class 1 Gen 2 Tag Protocol. Responsibilities expected to be addressed include providing means to manage readers to prevent reader-to-reader collisions and facilitate "scouring" to find tags. This includes management of power levels, carrier frequencies, "sessions" (as that term is defined in the UHF Class 1 Gen 2 Tag protocol), and protocol parameters. How these responsibilities are divided (or duplicated) between the Reader Protocol Interface and the Reader Management Interface is TBD.

9.1.6 Reader Management Interface (Interface)

Normative references:

- EPCglobal Working Draft: [RM1.0]

Responsibilities:

- Provides means to query the configuration of an RFID Reader, such as its identity, number of antennas, and so forth.
- Provides means to monitor the operational status of an RFID Reader, such as the number of tags read, status of communication channels, health monitoring, antenna connectivity, transmit power levels, and so forth.

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[1] Several of these responsibilities are described using text adapted from [SLRRP], which the authors gratefully acknowledge.

- Provides means to control configuration of an RFID Reader, such as enabling/disabling specific antennas or features, and so forth.
- May provide means to access RFID Reader management functions including discovery, firmware/software configuration and updates, and managing reader power consumption.

As the specification of this interface evolves to fully exploit features of the UHF Class 1 Gen 2 Tag Protocol, it is expected that it will gain additional responsibilities including providing means to manage readers to prevent reader-to-reader collisions and facilitate "scouring" to find tags. This includes management of power levels, carrier frequencies, "sessions" (as that term is defined in the UHF Class 1 Gen 2 Tag protocol), and protocol parameters. How these responsibilities are divided (or duplicated) between the Reader Protocol Interface and the Reader Management Interface is TBD.

Management of roles above the RFID Reader role is not currently addressed by EPCglobal standards, but may be considered in the future as warranted.

9.1.7 Reader Management (Role)

Responsibilities:

- Monitors the operational status of one or more RFID Readers within a deployed infrastructure.
- Manages the configuration of one or more RFID Readers.
- Carries out other RFID Reader management functions including discovery, firmware/software configuration and updates, and managing reader power consumption.

9.1.8 Filtering & Collection (Role)

The Filtering & Collection role coordinates the activities of one or more RFID Readers that occupy the same physical space and which therefore have the possibility of radio-frequency interference.

Responsibilities:

- Receives raw tag reads from one or more RFID Readers.
- Carries out processing to reduce the volume of EPC data, transforming raw tag reads into streams of events more suitable for application logic than raw tag reads. Examples of such processing include filtering (eliminating some EPCs according to their identities, such as eliminating all but EPCs for a specific object class), aggregating over time intervals (eliminating duplicate reads within that interval), grouping (e.g., summarizing EPCs within a specific object class), counting (reporting the number of EPCs rather than the EPC values themselves), and differential analysis (reporting which EPCs have been added or removed rather than all EPCs read).
- Determines which processing operations as described above may be delegated to the RFID Reader, and which must be performed by the Filtering & Collection role itself.

Implicit in this responsibility is that the Filtering & Collection role knows the capabilities of associated RFID Readers.

- Decodes raw tag values into URI representations defined by the Tag Data Specification. May use the Tag Data Translation Interface (Section 9.1.20) to obtain machine-readable rules for doing so.
- Maps between "logical reader names" and physical resources such as reader devices and/or specific antennas.
- When the Filtering & Collection role is accessed by more than one client application, mediates between multiple client application requests for data when those requests involve the same set or overlapping subsets of RFID Readers.
- Sets and controls the strategy for finding tags employed by RFID Readers.
- May coordinate the operation of many readers and antennas within a local region in which RFID Readers may affect each other's operation; e.g., to minimize interference. For example, this role may control when specific readers are activated so that physically adjacent readers are not activated simultaneously. In another example, this role may make use of reader- or tag protocol-specific features, such as the "sessions" feature of the UHF Class 1 Gen 2 Tag Protocol, to minimize interference.

The Filtering & Collection role has many responsibilities. The EPCglobal Architecture Framework currently provides standard interfaces to access some, but not all, of these responsibilities. Specifically:

- The Filtering & Collection (ALE) Interface (Section 9.1.9) provides a standard interface that applies to a large collection of use cases in which RFID Tags are inventoried (i.e., where the EPCs carried on the tags are read).
- The ALE Interface does not currently support use cases in which tags are written or killed, in which the kill or lock passwords are maintained, or in which "user data" or TID memory on the tags is read or written. These are expected to be addressed by future specifications, possibly new interfaces adjacent to the ALE Interface, or possibly by extending the ALE interface itself.
- Management of the Filtering & Collection role is not yet addressed by any EPCglobal specification. This includes controlling aspects of coordination the activities of multiple readers to minimize interference, setting parameters that govern inventorying strategies, control over Tag Protocol-specific features, and so on.

9.1.9 Filtering & Collection (ALE) Interface (Interface)

The Filtering & Collection (ALE) Interface provides a standard interface to the Filtering & Collection role that applies to a large collection of use cases in which RFID Tags are inventoried (i.e., where the EPCs carried on the tags are read). It does not apply to other use cases, as explained in the previous section.

Normative references:

- EPCglobal Proposed Standard: [ALE1.0]

Responsibilities:

- Provides means for one or more client applications to request EPC data from one or more data sources.
- Insulates client applications from knowing how many readers/antennas, and what makes and models of readers are deployed to constitute a single, logical data source.
- Provides declarative means for client applications to specify what processing to perform on EPC data, including filtering, aggregation, grouping, counting, and differential analysis, as described in Section 9.1.8.
- Provides a means for client applications to request data on demand (synchronous delivery) or as a standing request (asynchronous delivery).
- Provides means for multiple client applications to share data from the same reader or readers, without prior coordination between the applications.
- Provides a standardized representation for client requests for EPC data, and a standardized representation for reporting filtered, collected EPC data.

9.1.10 EPCIS Capturing Application (Role)

Responsibilities:

- Recognizes the occurrence of EPC-related business events, and delivers these as EPCIS data.
- May coordinate multiple sources of data in the course of recognizing an individual EPCIS event. Sources of data may include filtered, collected EPC data obtained through the Filtering & Collection Interface, other device-generated data such as barcode data, human input, and data gathered from other software systems.
- May control the carrying out of actions in the physical environment, including writing RFID tags and controlling other devices. (When tag writing and related features are addressed in a future version of the Filtering & Collection Interface, as noted in Section 9.1.8, the EPCIS Capturing Application may use the Filtering & Collection Interface to carry out some of these responsibilities.)

9.1.11 EPCIS Capture Interface (Interface)

Normative references:

- EPCglobal Working Draft: [EPCIS1.0]

Responsibilities:

- Provides a path for communicating EPCIS events generated by EPCIS Capturing Applications to other roles that require them, including EPCIS Repositories, internal EPCIS Accessing Applications, and Partner EPCIS Accessing Applications.

9.1.12 EPCIS Query Interface (Interface)

Normative references:

- EPCglobal Working Draft: [EPCIS1.0]

Responsibilities:

- Provides means whereby an EPCIS Accessing Application can request EPCIS data from an EPCIS Repository or an EPCIS Capturing Application, and the means by which the result is returned.
- Provides a means for mutual authentication of the two parties.
- Reflects the result of authorization decisions taken by the providing party, which may include denying a request made by the requesting party, or limiting the scope of data that is delivered in response.

9.1.13 EPCIS Accessing Application (Role)

Responsibilities:

- Carries out overall enterprise business processes, such as warehouse management, shipping and receiving, historical throughput analysis, and so forth, aided by EPC-related data.

9.1.14 EPCIS Repository (Role)

Responsibilities:

- Records EPCIS-level events generated by one or more EPCIS Capturing Applications, and makes them available for later query by EPCIS Accessing Applications.

9.1.15 Object Name Service (ONS) Interface (Interface)

Normative references:

- EPCglobal Working Draft: [ONS1.0]

Responsibilities:

- Provides a means for looking up a reference to an EPCIS service or other service that is provided by the EPC Manager of a specific EPC.

9.1.16 Local ONS (Role)

Responsibilities:

- Fulfills ONS lookup requests for EPCs within the control of the enterprise that operates the Local ONS; that is, EPCs for which the enterprise is the EPC Manager.

See also the discussion of ONS in Section 7.3.

9.1.17 ONS Root (Core Service)

Responsibilities:

- Provides the initial point of contact for ONS lookups.
- In most cases, delegates the remainder of the lookup operation to a Local ONS operated by the EPC Manager for the requested EPC.
- May completely fulfill ONS requests in cases where there is no local ONS to which to delegate a lookup operation.
- Provides a lookup service for 64-bit Manager Index values as required by the EPC Tag Data Specification.

See also the discussion of ONS in Section 7.3.

9.1.18 Manager Number Assignment (Core Service)

Responsibilities:

- Ensures global uniqueness of EPCs by maintaining uniqueness of EPC Manager Numbers assigned to EPCglobal Subscribers
- Assigns new EPC Manager Numbers as required by EPCglobal Subscribers.

9.1.19 Tag Data Translation Schema (Core Service)

Normative references:

- EPCglobal Working Draft: [TDT1.0]

Responsibilities:

- Provides a machine-readable file that defines how to translate between EPC encodings defined by the EPC Tag Data Specification (Section 9.1.2). EPCglobal provides this file for use by End-users, so that components of their infrastructure may automatically become aware of new EPC formats as they are defined.

9.1.20 Tag Data Translation Interface (Interface)

Normative references:

- EPCglobal Working Draft: [TDT1.0]

Responsibilities:

- Encodes in machine-readable form all of the rules that define how to translate between EPC encodings defined by the EPC Tag Data Specification (Section 9.1.2).

9.1.21 EPCIS Discovery (Core Service – TBD)

Note that "EPCIS Discovery" is not yet a defined part of the EPCglobal Architecture Framework, but rather a placeholder for functionality that is envisioned for the EPCglobal Network but not yet architected. The responsibilities enumerated below are an envisioned set of responsibilities, but it is not yet known if this list is complete or accurate, nor how many distinct roles and interfaces will ultimately be required to carry out these responsibilities. Moreover, while "EPCIS Discovery" is labeled an EPCglobal Core Service, this is also just a placeholder, and the final set of responsibilities may be addressed by a combination of EPCglobal Core Services and services operated by EPCglobal Subscribers.

Responsibilities:

- Provides a means to locate all EPCIS services that may have information about a specific EPC.
- May provide a cache for selected EPCIS data.
- Enforces authorization policies with respect to access of the aforementioned data.

9.1.22 Subscriber Authentication (Core Service – TBD)

Note that "Subscriber Authentication" is not yet a defined part of the EPCglobal Architecture Framework, but rather a placeholder for functionality that is envisioned for the EPCglobal Network but not yet architected. The responsibilities enumerated below are an envisioned set of responsibilities, but it is not yet known if this list is complete or accurate, nor how many distinct roles and interfaces will ultimately be required to carry out these responsibilities.

Responsibilities:

- Authenticates the identity of an EPCglobal Subscriber.
- Provides credentials that one EPCglobal Subscriber may use to authenticate itself to another EPCglobal Subscriber, without prior arrangement between the two Subscribers.
- Authenticates participation in network services through validation of active EPCglobal Subscription.

9.1.23 Filtering & Collection Management Interface (Interface – TBD)

In Section 9.1.6 it is noted that management of roles above the RFID Reader role is not currently addressed by EPCglobal standards, but may be considered in the future as warranted. The Filtering & Collection Management Interface shown in the diagram at the beginning of this section is a placeholder for future work that may arise in this area. The responsibilities enumerated below are an envisioned set of responsibilities, but it is not yet known if this list is complete or accurate, nor how many distinct roles and interfaces will ultimately be required to carry out these responsibilities.

Responsibilities:

- Provides means to query the configuration of systems that carry out Filtering & Collection responsibilities.

- Provides means to monitor the operational status of systems that carry out Filtering & Collection responsibilities.
- Provides means to control configuration of systems that carry out Filtering & Collection responsibilities.

10 Summary of Unaddressed Issues

As noted in Section 1 and throughout the document, there are technical needs that are believed to exist based on the analysis of known use cases, where those needs are not yet fully addressed by the EPCglobal Architecture Framework. In these cases, the architectural approach has not yet been finalized, and therefore work on developing standards or designing additional Core Services has not yet begun, though architectural analysis is underway within the Architecture Review Committee. This section summarizes the known unaddressed issues, and will serve as a starting point for continued refinement of the EPCglobal Architecture Framework.

The following list of issues is *not* intended to suggest the relative importance or priority of any issue.

10.1 EPCIS "Discovery"

The EPCIS Interface provides the means for one Subscriber to query another for EPC-related information. As discussed in Section 7.1, there are several ways a Subscriber might locate the relevant EPCIS Services in a given situation.

The EPCglobal Architecture Framework does not currently provide a means to locate EPCIS Services in the most general situations arising from multi-party supply chains, in which several different organizations may have relevant data about an EPC but the identities of those organizations are not known in advance. Sections 7.1 and 9.1.20 discuss some of the thinking that has gone on in this area, but the EPCglobal Architecture Framework does not yet address these requirements.

10.2 Subscriber Authentication

Section 7.1 also points out the need for subscribers to mutually authenticate each other when they are involved in EPCIS exchanges. It is desirable for this authentication to be as easy as possible for a subscriber to implement. In particular, it is undesirable if each subscriber has to make prior arrangements with every other subscriber that might be involved in a future EPCIS exchange; instead, it is better if each subscriber need only register once with a central authority and thereafter be able to mutually authenticate with any other subscriber.

The EPCglobal Architecture Framework does not yet address this requirement, but some of the thinking is captured in Sections 7.1 and 9.1.22.

10.3 RFID Reader Coordination

The UHF Class 1 Gen 2 Tag Protocol provides a number of features designed to improve the performance of RFID Readers, especially when many readers are deployed in close physical proximity. These features serve to minimize reader-to-reader collisions, and facilitate "scouring" algorithms to find tags. Among the features provided for these ends are control over power management, carrier frequencies, "sessions" that help insure one reader does not interfere with another reader's conversation with the same tag, and other protocol parameters.

The Reader Protocol and Reader Management specifications currently under development do not specifically address these new features, nor does the EPCglobal Architecture Framework specify how these features would be exploited at an architectural level (e.g., by giving some responsibility to the Filtering & Collection role, or possibly to higher-level roles or new roles).

10.4 RFID Tag-level Security and Privacy

Sections 3.6 and 3.7 discuss EPCglobal Network goals of security and privacy. The UHF Class 1 Generation 2 Tag Protocol supports specific RFID Tag features designed to further security and privacy goals. These features include a "kill" feature with an associated kill password, a "lock" feature, and an access control password.

The EPCglobal Architecture Framework does not currently discuss how these features affect the architecture above the level of the Reader Protocol, nor is there any architectural discussion of how the goals of security and privacy are address through these or other features. In particular, it is not clear how the passwords required to operate the "kill" and "lock" features are to be distributed through the network to reach the places where they are required.

It should be noted that the "kill" and "lock" features are only components of a comprehensive privacy policy, not a complete solution to privacy issues facing the EPCglobal Network. The EPCglobal Public Policy Steering Committee (PPSC) is responsible for creating and maintaining the EPCglobal Privacy Policy; readers should refer to PPSC documents for more information.

10.5 "User Data" in RFID Tags

The EPCglobal Architecture Framework discusses the use of RFID Tags that are used to hold an EPC code associated with an object to which the tag is affixed. The UHF Class 1 Generation 2 Tag Protocol supports RFID Tags that contain additional "user data" besides the EPC code.

The EPCglobal Architecture Framework does not currently discuss how RFID Tag "user data" is to be exploited at any level of the architecture.

10.6 Tag Writing, Killing, Locking above the Reader Protocol Layer

Reading (apart from reading EPCs), writing, locking, and killing of RFID Tags, as well as maintenance of the kill and access passwords, are currently addressed by the Tag Protocol and Reader Protocol, but not yet at higher layers of the architecture framework. See Section 9.1.8 for further discussion.

10.7 Master Data for RFID Tag Manufacture Data

The UHF Class 1 Generation 2 Tag Protocol provides for a read-only "tag ID" (TID) field that is written at RFID Tag manufacture time. The TID is intended to provide information about the manufacture of the tag, including the identity of the tag manufacturer and other information. This information would be associated with the TID in an external database, maintained by EPCglobal or some other authority.

The EPCglobal Architecture Framework does not currently provide a specification for the TID or associated information. Existing architecture components (e.g., ONS) might be useful for this purpose.

11 References

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12 Glossary

This section provides a summary of terms used within this document. For fuller definitions of these terms, please consult the relevant sections of the document. See also the whole of Section 9, which defines all roles and interfaces within the EPCglobal Architecture Framework.

Term	Section	Meaning
EPCglobal Architecture Framework	1	A collection of interrelated standards ("EPCglobal Standards"), together with services operated by EPCglobal ("EPCglobal Core Services"), all in service of a common goal of enhacing the supply chain through the use of Electronic Product Codes (EPCs).

Term	Section	Meaning
EPCglobal Standards	1	Specifications for hardware and software interfaces through which components of the EPCglobal Architecture Framework interact. EPCglobal Standards are developed through the EPCglobal Standards Development Process. EPCglobal standards are implemented both by EPCglobal Core Services and by systems deployed by end user companies and their solution providers.
EPCglobal Core Services	1	Network-accessible services, operated by EPCglobal and its delegates, that provide common services to all subscribers of the EPCglobal Network, through interfaces defined as part of the EPCglobal Architecture Framework.
EPCglobal Network	1	An informal marketing term used to refer loosely to EPCglobal Subscribers and their interaction with EPCglobal and with each other, where that interaction takes place directly through the use of EPCglobal Standards and indirectly through EPCglobal Core Services.
EPCglobal Subscriber	1	An organization that participates in the EPCglobal Network through the use of EPCglobal Core Services, or through participation in the EPCglobal Standards Development Process. An EPCglobal Subscriber may be an End-User, a Solution Provider, or both.
End-user	1	An EPCglobal Subscriber that employs EPCglobal Standards and EPCglobal Core Services as a part of its business operations.
Solution Provider	1	An organization that implements systems on behalf of end-users that use EPCglobal Standards and EPCglobal Core Services. A Solution Provider may or may not itself be an EPCglobal Subscriber.
Electronic Product Code (EPC)	1	A unique identifier for a physical object, unit load, location, or other identifiable entity playing a role in business operations. Electronic Product Codes are assigned following rules designed to ensure uniqueness despite decentralized administration of code space, and to accommodate legacy coding schemes in common use. EPCs have multiple representations, including binary forms suitable for use on RFID tags, and text forms suitable for data exchange among enterprise information systems.

Term	Section	Meaning
Registration Authority	4.1	The organization responsible for the overall structure and allocation of a namespace. In the case of the Electronic Product Code, the Registration Authority is EPCglobal. The Registration Authority delegates responsibility for allocating portions of the namespace to an Issuing Agency.
Issuing Agency	4.1	An organization responsible for issuing blocks of codes within a predefined portion of a namespace. For Electronic Product Codes, Issuing Agencies include GS1 (for GS1-based codes such as SGTIN, SSCC, etc) and the US Department of Defense (for DoD codes). An Issuing Agency issues a block of EPCs to an EPC Manager, who may then commission individual EPCs without further coordination.
EPC Manager	5.2	An EPCglobal Subscriber that has been allocated a block of Electronic Product Codes by an Issuing Agency.
EPC Manager Number	5.3	A number that uniquely identifies one or more blocks of Electronic Product Codes issued to an EPC Manager.
Object Class	5.5	A group of objects that differ only in being separate instances of the same kind of thing; for example, a product type or SKU.

13 Questions Raised During Review

A draft of this document was reviewed by the EPCglobal community between April 15, 2005 and May 18, 2005. Many of the comments received led to clarifications or other changes in the body of this document. This section enumerates other comments that are not specifically addressed elsewhere within the document.

13.1 Questions about the Electronic Product Code and its use

In Section 4.1, EPC is described as a federation of several naming structures. Isn't it more accurate to say that EPC functions as a multi-industry naming structure by providing one naming structure standard?

Saying that EPC provides "one naming structure standard" might easily be misconstrued. It is important to recognize that EPC does not impose a *single* numbering structure on all industries, but rather federates existing numbering structures including the GS1 family of coding schemes, the US Department of Defense's CAGE/DoDAAC scheme, etc. This is in contrast to the original conception of the EPC as proposed by the MIT Auto-ID Center, which *was* a single numbering structure. The evolution from the single numbering structure model to the federated model was a key factor in the acceptance of EPC for most of the participating industries.

In Section 4.1 it is stated that EPCs are globally unique. Yet it also says that in the case of an SSCC, the EPC might not be unique. Will the allocation rules for SSCC or the definition of EPC have to change to resolve this apparent contradiction?

Because of the End-user community's desire to have an EPC representation that includes existing coding schemes such as SSCC, some compromise was needed. As stated in Section 4.1, each coding scheme that is federated within the EPC system may specify its own rules as regards uniqueness over time. Global uniqueness over time is a desirable goal for any coding scheme, but when existing schemes are federated into the EPC structure they may bring along their own restrictions. In the case of SSCC, current practice together with the size limitations of the SSCC imply that they are recycled periodically. Since it is not practical to change the SSCC, the EPCglobal Architecture Framework must recognize that the SSCC variety of EPC is not globally unique over all time. This does not, however, compromise the uniqueness guarantees of other kinds of EPCs, such as SGTINs. Since an EPC always carries an indication of coding scheme, information processing systems can be aware of the restrictions that apply to any particular EPC.

Some End-users want to use the same EPC for identical objects, or two EPCs for a single object. Can the EPCglobal Architecture Framework handle such requests?

Because the EPC is intended to *uniquely* identify an object (see Section 4.1), it is not permitted to use the same EPC for identical objects. As for assigning two EPCs to a single object, certain cases of this are discussed in Section 4.1.

In other instances, an End-user may wish to affix two or more RFID tags to the same physical object, all bearing the same EPC code, in order to improve the chances of reading the EPC. In this case there is still one EPC for one object, and so this is permitted by the EPCglobal Architecture Framework. Whether it is technically feasible depends on the Tag Protocol being used (e.g., this will work using UHF Class 1 Gen 2 tags, but not using the older Class 1 tags).

The UHF Class 1 Gen 2 Tag Protocol allows an optional memory bank for user data. Doesn't this conflict with the statement in Section 4.1 the EPC is a lightweight identifier with no additional information? How will the optional user data segment be structured?

The statement in Section 4.1 is that the *EPC* is lightweight. The user data on a UHF Class 1 Gen 2 tag is not part of the EPC, but rather accompanies the EPC on the tag. This is an example of "information … associated with the EPC through other means" as mentioned in Section 4.1; in this case, the means of association is that the EPC and the user data are carried on the same RFID tag.

The structure and contents of the user data memory of a UHF Class 1 Gen 2 tag will be defined in a future version of the EPC Tag Data Standard, or by a new specification created by that Working Group.

Section 5.2 enumerates some responsibilities of the EPC Manager with respect to the EPC codes that it manages. Doesn't the EPC Manager have responsibilities, including the providing (via EPCIS) of EPC master data like class level data or 'as built' specifications, as well as establishing initial kill and access passwords?

While it is true that these are typically things that an EPC Manager does, the details are specific to a particular industry. Section 5.2 only enumerates the responsibilities that are necessary in all cases to insure the integrity of the EPCglobal Network.

13.2 Questions about EPCIS and ONS

The document does not contain any reference to the Physical Markup Language (PML). Is PML not considered part of the architectual framework?

PML was a data exchange standard proposed by the Auto-ID Center prior to the creation of EPCglobal. Within the EPCglobal Architecture Framework, PML has been superceded by EPCIS, in particular the EPCIS Data Specification (see Sections 5.6 and 9.1.12).

How is temporary data, that is not stored on an RFID Tag, maintained within the EPCglobal Network. For example, suppose that a reader in a distribution center (DC) is able to determine that a certain RFID Tag, when detected, is either leaving or entering the DC. How can this information be accessed and used by other EPCglobal Subscribers?

This is exactly the role of EPCIS. See Sections 5.6, 9.1.12, 9.1.10, 9.1.11, 9.1.13, and 9.1.14.

ONS only contains references to EPCIS services of the enterprise that issued a given EPC. When an object having an EPC "travels" in the supply chain, multiple enterprises read the EPC and keep information about it. This information will be stored in multiple EPCIS services which must be referenced by the ONS.

This is a common misunderstanding about ONS. It is true that ONS only refers to the EPCIS services of the EPC Manager (that is, the enterprise that issued a given EPC), and so ONS does *not* provide a means to find EPCIS services of other enterprises that may have information about a given EPC. This latter responsibility is the subject of "EPCIS Discovery" services, which are still under development within EPCglobal. See Sections 7.1 and 9.1.20.

Section 7.1 describes "following the chain" as a way for discovering what EPCIS services contain data about a given EPC. Are the backwards and forwards links required to follow the chain being implemented as part of EPCIS?

The EPCIS Working Group anticipates that EPCIS event data may contain "business transaction identifiers" (e.g., a purchase order identifier) that could be used to follow the chain.

Is "following the chain" as described in Section 7.1 the standard technique in the EPCglobal Network for locating information other than that in the EPC Manager's EPCIS? "Following the chain" seems fragile.

The ARC recognizes that "following the chain" is fragile, which is why effort is underway to define the more robust "EPCIS Discovery" function (see Sections 7.1 and 9.1.20). "Following the chain" is viable in many situations, however, and so it is included in this document.

Who is developing the EPCIS Query Interface? When is it expected to be available?

The EPCIS Query Interface is under development within the EPCIS Phase 2 Working Group within the Software Action Group. Please contact the Working Group co-chairs for information about schedule.

13.3 Questions about Infrastructure Standards

How are operational parameters handled within the EPCglobal Architecture Framework? For example, the UHF Class 1 Gen 2 Tag Protocol requires that each reader select a session in which to singulate tags. Sessions must be managed at the level of a physical site. Which EPCglobal specification(s) governs the choice of session, and how does this information flow down to each and every reader?

The EPCglobal Architecture Framework provides two interfaces for control of reader parameters such as these: the Reader Protocol and the Reader Management Interface. At the time of this writing, the respective Working Groups have not yet addressed normative specifications for choice of session and how this is to be coordinated across multiple readers within a site. This is expected to be among the topics addressed as these Working Groups revise their specifications to encompass more Gen 2 features.

13.4 Questions about Security and Privacy

Where in the diagram of Section 9 are components that provide functions such as authentication, access control, validation, privacy protection of individuals and corporations, and so on?

In general, security functions such as these are not distinct roles within the EPCglobal Architecture Framework. Rather, each role includes responsibilities related to security and privacy. For example, an RFID Tag (Section 9.1.1) has responsibilities related to kill and lock codes, and the EPCIS Query Interface (Section 9.1.12) has responsibilities related to authentication and authorization in cross-enterprise data exchange. The individual EPCglobal Standards define these responsibilities in more detail. In other cases, it is acknowledged that there are security and privacy issues not yet fully addressed in the EPCglobal Architecture Framework, and these are noted within this document (see, for example, Sections 9.1.22, 10.2, and 10.4).

Section 10.4 states that the network aspects of "kill" and "lock" are open. Retailers might face a privacy issue here, if tags of tagged cases cannot be killed at the time of checkout.

The ARC agrees with this concern. Section 10.4 merely reflects the reality that this is a topic of current work, and so it is not possible to say anything more definitive at this time.

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