Introduction to EPC & EPC Architecture

(http://www.epcglobalinc.org)

Athens Information Technology

EPC Codes

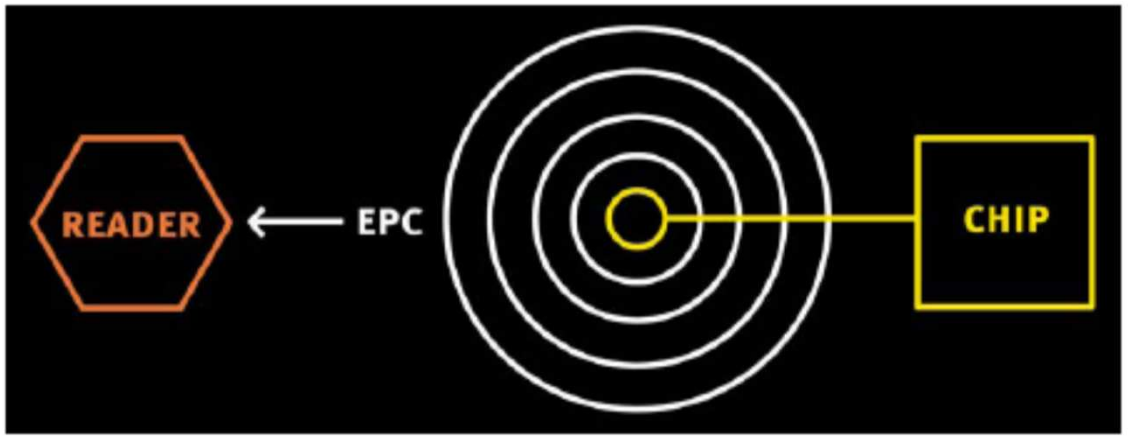
- Goods today have bar codes
- RFID systems use the Electronic Product Code (EPC)
- EPC is a modern day replacement of the Universal Product Code (UPC)
- Each product tag has a unique embedded EPC number

EPC Protocol

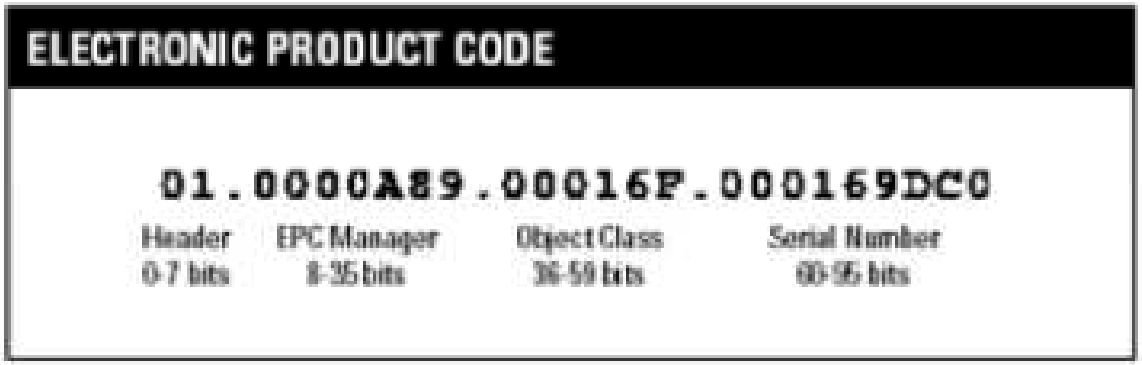
- Developed at MIT's Auto-ID Center in 2000
- Tells how data is to be segregated and stored on the tag (numbering scheme)
- Determines how the tags and readers communicate

Tags and Readers

- The reader ‘zaps’ the chip with a radio wave, the chip replies with its EPC
  - EPC is the only thing stored on the chip
  - The chip is passive (no power)



EPC (1)


ELECTRONIC PRODUCT CODE
01.0000A89.00016F.000169DC0
Header
0-7 bits
EPC Manager
8-35 bits
Object Class
36-59 bits
Serial Number
60-95 bits

EPC (2)

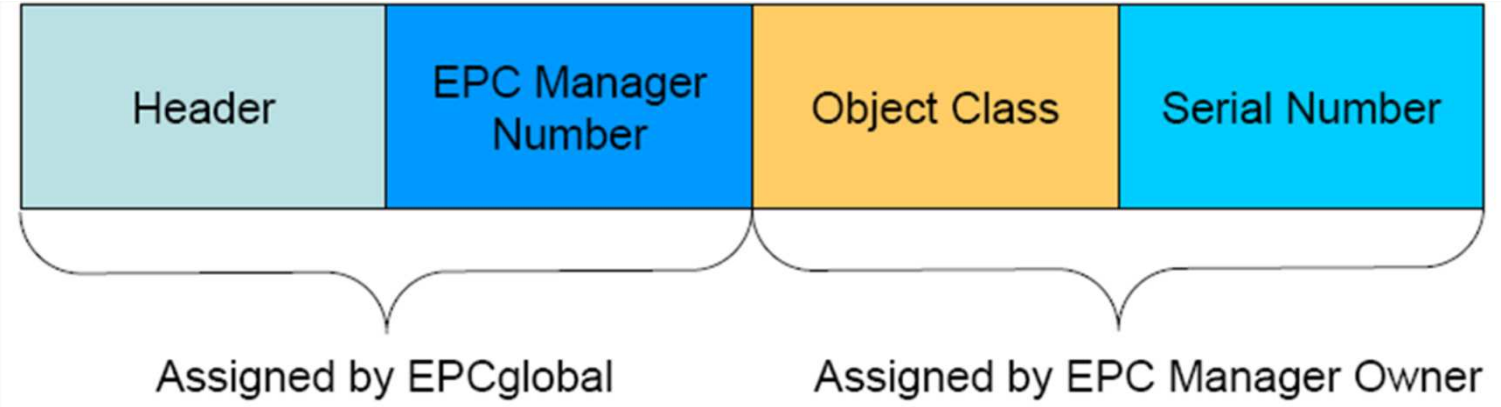
- Header
  - This tells the RFID reader what type of number follows
- EPC Manager Number
  - Identifies the company or company entity
- Object class
  - Next is the object class, similar to a stock-keeping unit, or SKU

EPC (3)

- Serial number
  - Lastly (and most importantly) is a serial number, which is the specific instance of the object class being tagged
  - Thus, it identifies the item with the specific tag as that item (not just a type of item)

Basic Format

- Header
  - Identifies the length, type, structure, version, and generation of the EPC
- EPC Manager Number
  - Entity responsible for maintaining the subsequent partitions
- Object Class
  - Identifies a class of objects
- Serial Number
  - Identifies the instance



EPC Structure

- Encoded on radio frequency tags in bits
  - 0's and 1's
- Provides multiple formats for
  - Various bit length tags (64 and 96)
  - Accommodates existing identifiers
  - All formats support unique EPCs

Schemes Defined (v1.1)

- General Identifier (GID) GID-96 a serialized version of the GS1 Global Trade Item Number (GTIN) SGTIN-96 SGTIN-198
- GS1 Serial Shipping Container Code (SSCC) SSCC-96
- GS1 Global Location Number (GLN), SGLN-96 SGLN-195
- GS1 Global Returnable Asset Identifier (GRAI) GRAI-96 GRAI-170
- GS1 Global Individual Asset Identifier (GIAI) GIAI-96 GIAI-202 and
- DOD Construct DoD-96 96-bit format for
- General Identifier (GID)
- GID is not an EAN.UCC format

64-bit Tags

- Widely available today
- Being used in pilots
- A temporary measure for immediate and cost-effective implementation
- Forward compatible with 96 bit chips
- Has some constraints

General Identification Number (GID)

- The General Identifier (GID-96) is independent of any known, existing specifications or identity schemes
- The General Identifier is composed of three fields
  - The General Manager Number,
  - The Object Class, and
  - Serial Number
- Encodings of the GID include a fourth field, the header, to guarantee uniqueness in the EPC namespace.

	Header	General Manager Number	Object Class	Serial Number
GID-96	8	28	24	36
	0011 0101 (Binary value)	268,435,455 (Max. decimal value)	16,777,215 (Max. decimal value)	68,719,476,735 (Max. decimal value)

Serialized Global Trade Item Number (SGTIN)

- Derived from EAN.UCC GTIN (EAN.UCC Barcode-128)
- The Company Prefix is assigned by GS1 to a managing entity
- The Item Reference is assigned by the managing entity to a particular object class.
  - For the purposes of EPC Tag Encoding it is derived from the GTIN by concatenating the Indicator Digit of the GTIN and the Item Reference digits, and treating the result as a single integer
- The Serial Number is assigned by the managing entity to an individual object.
  - It is not part of the GTIN code, but is formally a part of the SGTIN.
  - SGTIN-96 against SGTIN-198

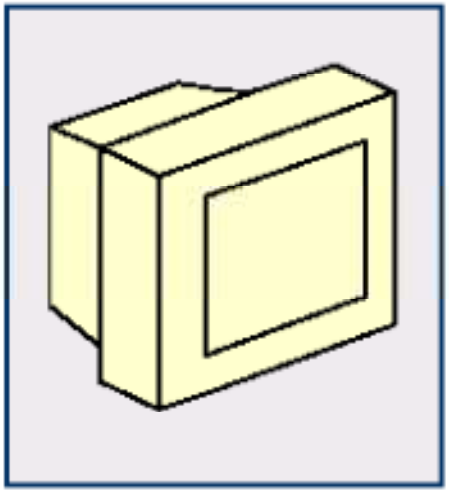
Example

- Start with a UPC
  - 614141 is the UPC Company Prefix
  - 00734 is the Item Reference
  - 9 is the Check Digit
  - 614141 00734 9
- Turn it into a Global Trade Item Number (GTIN)
  - Add “0” indicator and “0” number system carrier to build out full 14 digit format
  - 614141 00734 9
  - 0 0614141 00734 9

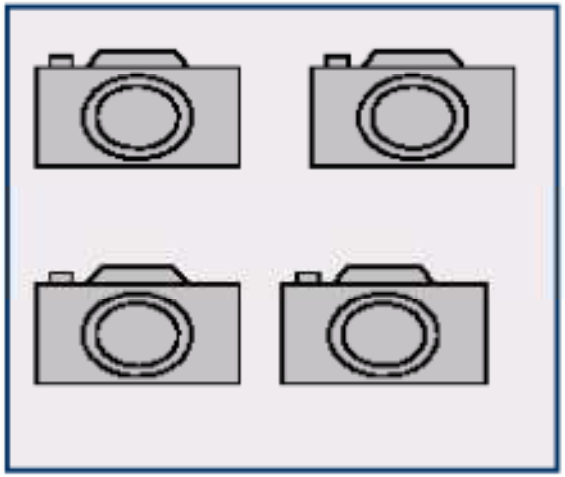
Using Filter Values

001 - Retail Consumer Trade Item

011 - Single Shipping/Consumer Trade Item Single



010 - Standard Trade Item Grouping



Filter Value

- Not part of the EPC identifier
- Used during RF reads to select or mask out types of EPC
- Screen out items not needed in distribution applications to improve RF reads
- Different for GTIN, SSCC, GLN formats
- Validated by GSMP early in 2005

Other Keys

- Other keys will be accommodated by EPC in additional formats
- US Department of Defense constructs
- Any other industry with unique numbering systems
- The formats must always result in unique EPCs

EPC functionality

Table 2-2 RFID Interface Protocols				
Protocol	*Corresponding Frequency*	*Capabilities*	*Pros*	*Cons*
Generation 1 Class 0	UHF	This is a read-only preprogrammed tag, which means that the end user can't write a new number to the tag.	Fast data communication protocol.	Preprogrammed tags increase administrative and logistics cost of affixing the correct tag to the correct item and also minimize a tag's flexibility.
Generation 1 Class 1	UHF and HF	Write once, read many (WORM)	Keep data in sequential order; manage data easier.	Can be written to only once.
ISO standard	LF, HF, and UHF	Read Only Tag Identifier with read, write, and lockable user memory to store object identifier and information.	Keep data in sequential order; manage data easier.	Does not account for the data structure but only how the tag and reader communicate.
Generation 2.0 Class 1	HF and UHF	WORM	Keep data in sequential order; manage data easier. More globally accepted protocol.	Can be written to only once.

Patrick J. Sweeney, "RFID For Dummies" April 2005

EPC Global Architecture Network

(According to the EPCglobal Architecture Framework EPCglobal Final Version 1.2)

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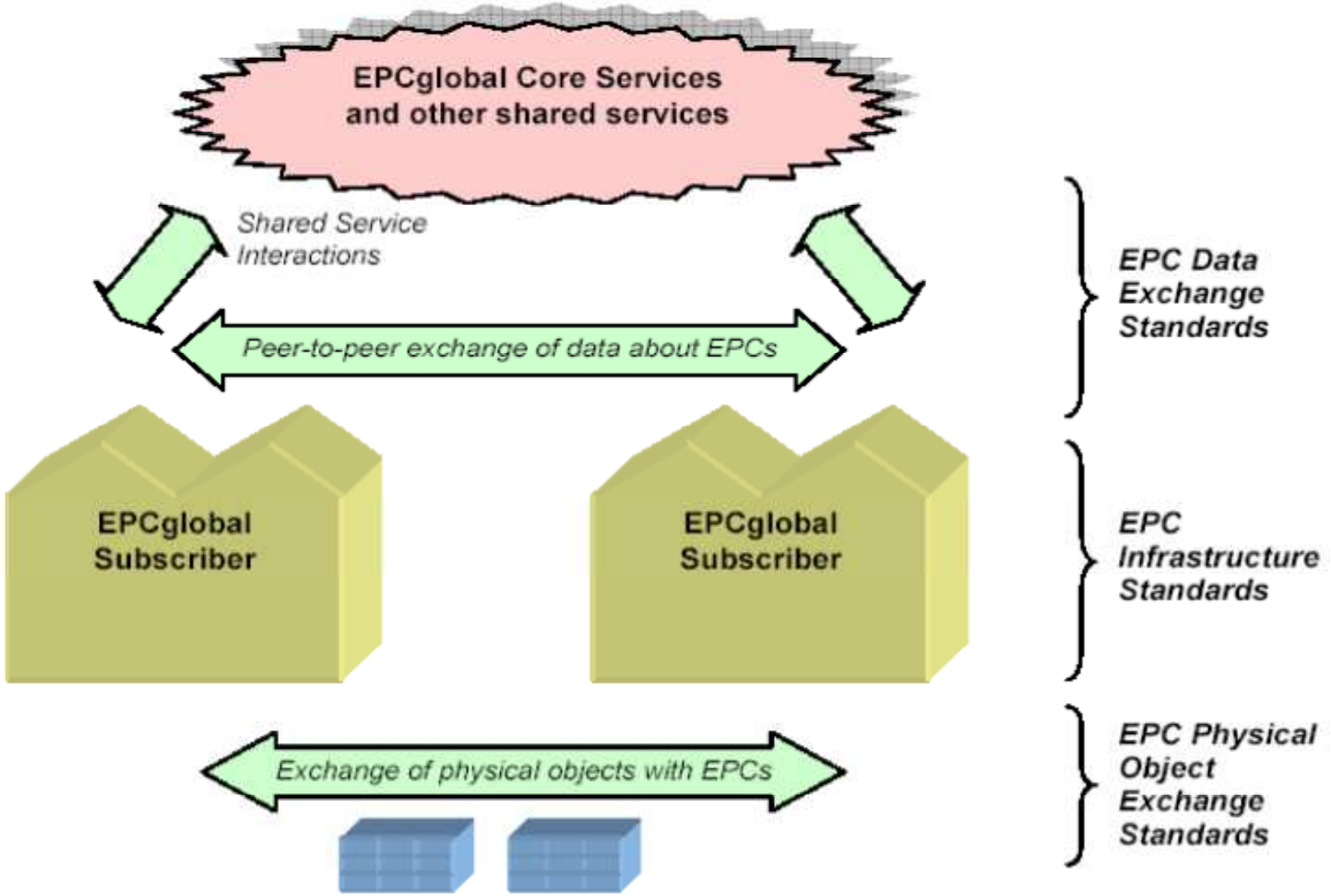
Agenda

- Enumerate each of the hardware, software, and data standards that are part of the EPCglobal Architecture Framework and show how they are related
- Define the top level architecture of EPCglobal Core Services
- Explain the underlying principles that have guided the design of individual standards and Core Service components within the EPCglobal Network
- Provide architectural guidance to end users and technology vendors seeking to implement EPCglobal Standards and to use EPCglobal Core Services
- More details
  - http://www.epcglobalinc.org/standards/architecture/architecture_1_2-framework-20070910.pdf

Architecture Framework Overview



EPC Physical Object Exchange

- Subscribers exchange physical objects that are identified with Electronic Product Codes (EPCs)
- Physical objects are trade goods
- Subscribers are parties in a supply chain for those goods

EPC Data Exchange

- Subscribers increase the visibility of physical objects outside their four walls
- The EPCglobal Architecture Framework defines EPC data exchange standards
- That provides a means for one subscriber to share data about EPCs with another through direct peer- to-peer interaction

EPC Infrastructure

- 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

Architecture Framework Standards (1)

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

Architecture Framework Standards (2)

Activity	Standard	Status	Reference
Data Exchange	Application Level Events (ALE)	In development	[ALE1.0]
	EPCIS Capture Interface	In development	[EPCIS1.0]
	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)

Role of Standards

- To facilitate the exchange of information and physical objects between trading partners
- To foster the existence of a competitive marketplace for system components
- To encourage innovation

Global Standards

- EPCglobal is committed to the creation and use of global standards
- EPCglobal standards are developed for global use

Open System

- The Intellectual Property policy of EPCglobal is designed to secure free and open rights to implement EPCglobal Standards

Platform Independence

- EPCglobal Architecture Framework can be implemented on heterogeneous software and hardware platforms
- 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

Scalability and Extensibility

- EPCglobal Architecture Framework is designed to scale to meet the needs of each end-user e.g.
  - Minimal pilot implementation conducted entirely within an End-user's four walls
  - Global implementation across entire supply chains

Security

- EPCglobal Architecture Framework is designed to promote a secure environment for operations inside and outside a company's four walls

Privacy

- EPCglobal Architecture Framework is designed to accommodate the needs of both individuals and corporations to protect confidential and private information
  - EPCglobal Public Policy Steering Committee (PPSC) is responsible for creating and maintaining the EPCglobal Privacy Policy
- EU RFID Privacy Policy
  - http://ec.europa.eu/information_society/policy/rfid/index_en.htm

Industry Architectures and Standards

- EPCglobal Architecture Framework is designed to work with and complement existing industry-wide architectures and standards.

Open, Community Process

- 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

Underlying Technical Principles

- Unique Identity
- Decentralized Implementation
- Layering of Data Standards – Verticalization
- Layering of Software Specifications – Technology Agnosticism
- Extensibility

Unique Identity

- Uniqueness
- Federation
- Representation independence
- Decentralized assignment
- Structure
- Light Weight

Decentralized Implementation

- The EPCglobal Architecture Framework is decentralized, meaning that logically centralized functions are distributed among one or more facilities serving individual EPCglobal Subscribers
- The key elements of decentralization in the EPCglobal Architecture Framework are the assignment of EPC codes, and the ONS lookup service

Layering of Data Standards – Verticalization (1)

- 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

Layering of Data Standards – Verticalization (2)

- Two important data standards
  - 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
  - EPCIS Data Specification
    - The framework elements include the abstract data model that lays out a general organization for master data and transactional event data

Extensibility

- A general design principle for all EPCglobal Standards is openness to Extension
- Extensions include both enhancements to the standards themselves
- 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

Architectural Foundations

- Electronic Product Code
- EPC Manager
- EPC Manager Number
- Embedding of Existing Codes
- Class Level Data versus Instance Level Data
- EPC Information Services (EPCIS)

Electronic Product Code

- Electronic Product Code
  - Ties together all data that flows within the EPCglobal Network
  - Plays a central part in every role and interface within the EPCglobal Architecture Framework

EPC Manager

- EPC Manager responsible for
  - Allocating new EPC from its assigned block
  - Associating it with a physical object or other entity
  - Maintaining the Object Name Service (ONS) records associated with blocks of EPCs it manages

EPC Manager Number

- Way an Issuing Agency grants a block of EPCs to an EPC Manager is by issuing the EPC Manager a single number
  - EPC Manager Number
- 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

EPC Information Services (EPCIS)

- EPCIS data can be divided into five categories
  - Static Data
  - Class-level Static Data
  - Instance-level Static Data
  - Transactional Data
  - Instance Observations
  - Quantity Observations
  - Business Transaction Observations

Architecture Framework Vs. System Architecture (1)

- EPCglobal Architecture Framework
  - Interrelated standards for hardware, software, and data interfaces (EPCglobal Standards)
  - Core services that are operated by EPCglobal and its delegates (EPCglobal Core Services)
  - 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
  - End-user system architecture may only need to employ a subset of the EPCglobal Standards and Core Services

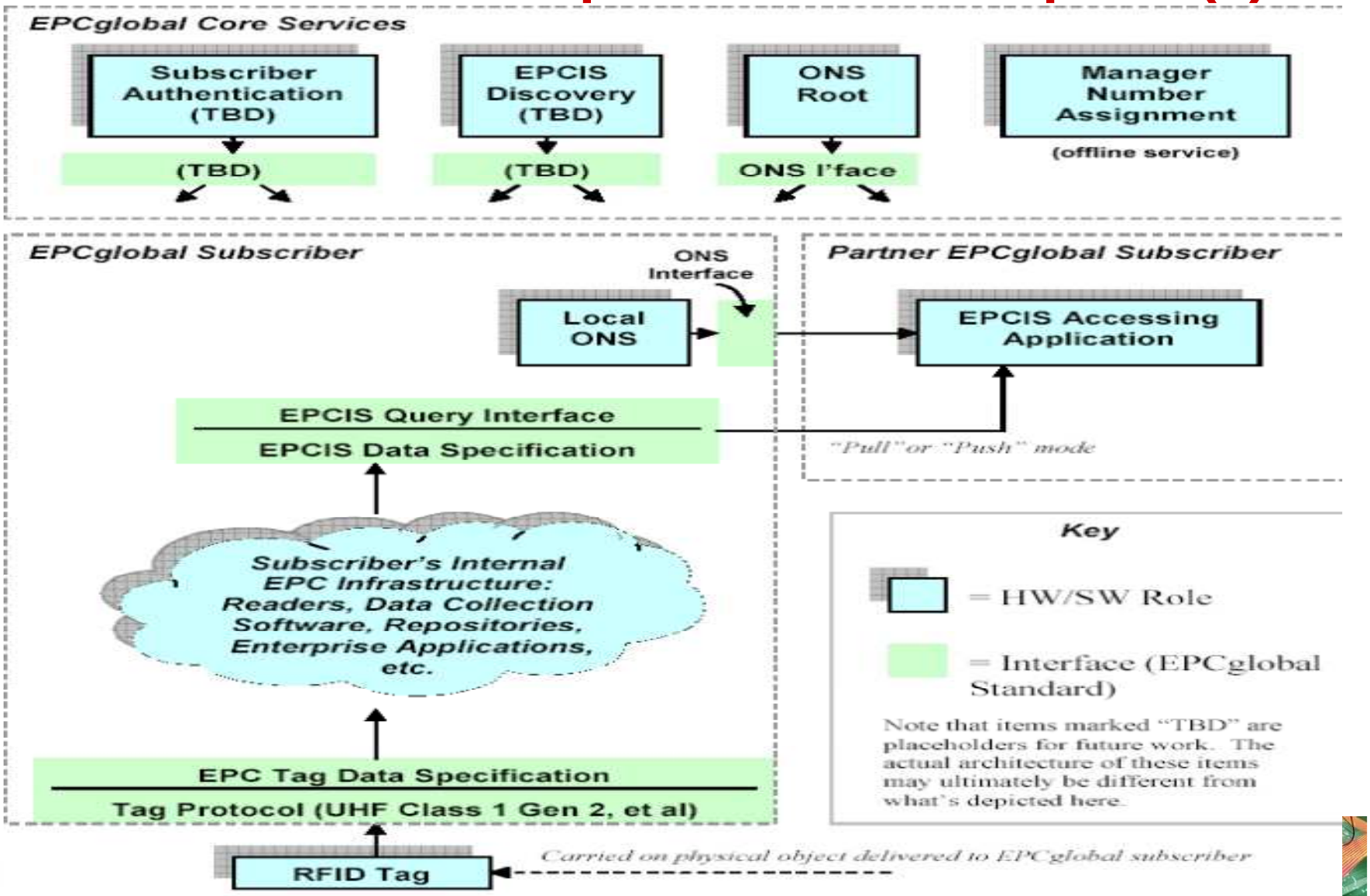
Architecture Framework Vs. System Architecture (1)

- Mapping between hardware and software roles Actual hardware or software components deployed by an end-user may not necessarily be one-to-one
- Roles may be carried out by an end user's legacy system components
  - May have additional responsibilities outside the scope of the EPCglobal Architecture Framework

Cross-Enterprise Vs. Intra-Enterprise

- Use of EPC Data Exchange between enterprises and EPC Object Exchange between enterprises, is necessary to interact with other subscribers
- Subscriber has much more latitude in its decisions surrounding adoption of the EPC Infrastructure standards as those standards do not affect parties outside the subscriber's own four walls

Data Flow Relationships – Cross-Enterprise (1)



Data Flow Relationships – Cross-Enterprise (2)

- Data Exchange Interactions
- Object Exchange Interactions
- ONS Interactions
- Number Assignment

Data Exchange Interactions (1)

- The EPCIS Accessing Application may
  - Know in advance exactly where to find the information
  - Know where to find the information it seeks based on information obtained previously

Data Exchange Interactions (2)

- 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
  - 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

Object Exchange Interactions

- 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

ONS Interactions (1)

- EPCglobal Subscriber wishes to locate an EPCIS service
  - Consults the Root ONS service controlled by EPCglobal
  - Root ONS service identifies the Local ONS service of the EPC Manager organization for that EPC
  - EPCglobal Subscriber then completes the lookup by consulting the Local ONS service, which provides the pointer to the EPCIS service in question

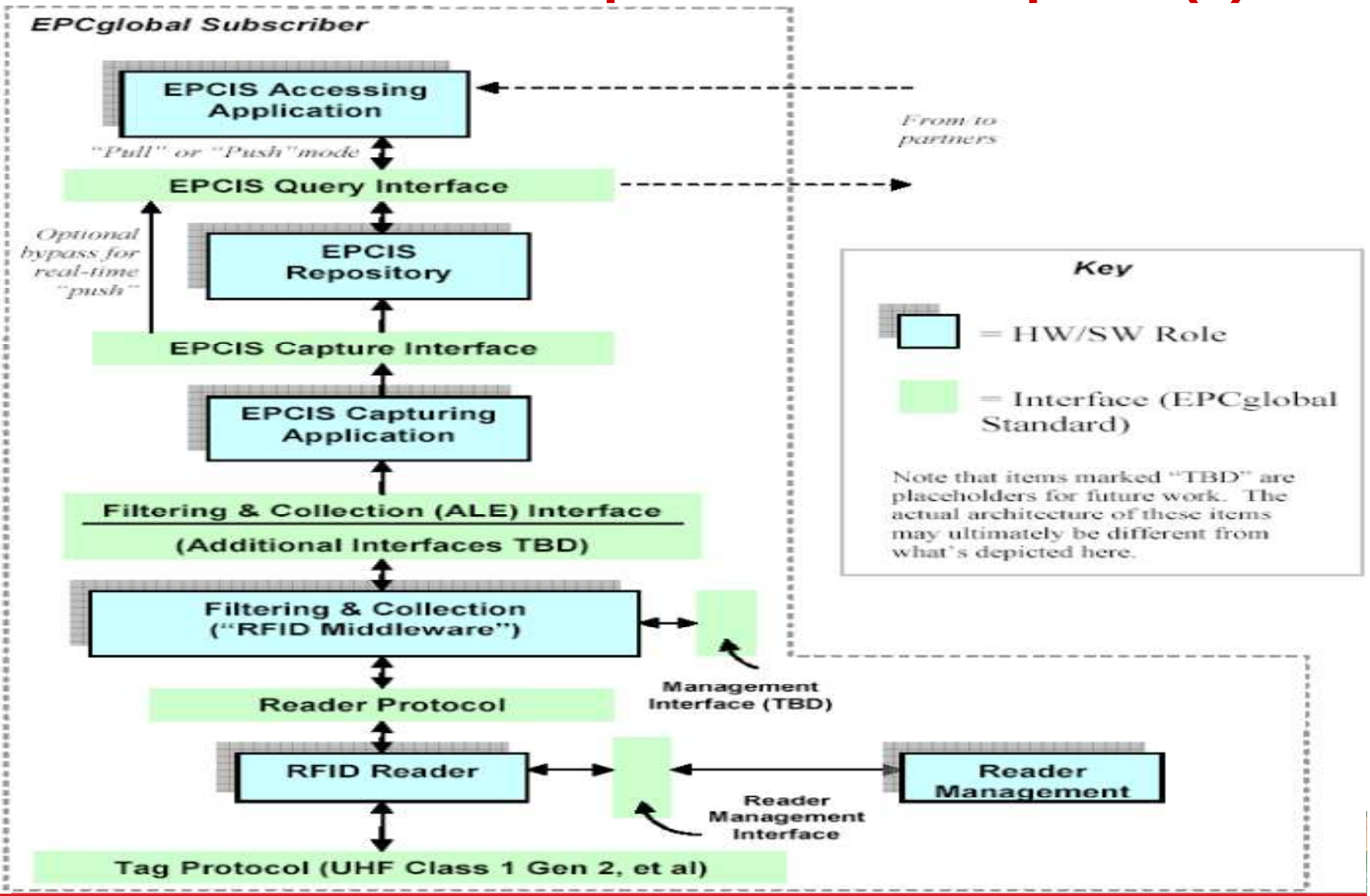
ONS Interactions (2)

- Implications
  - "Root ONS service" and "Local ONS service" as used above may each be implemented by multiple independent servers
  - 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

Number Assignment

- 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

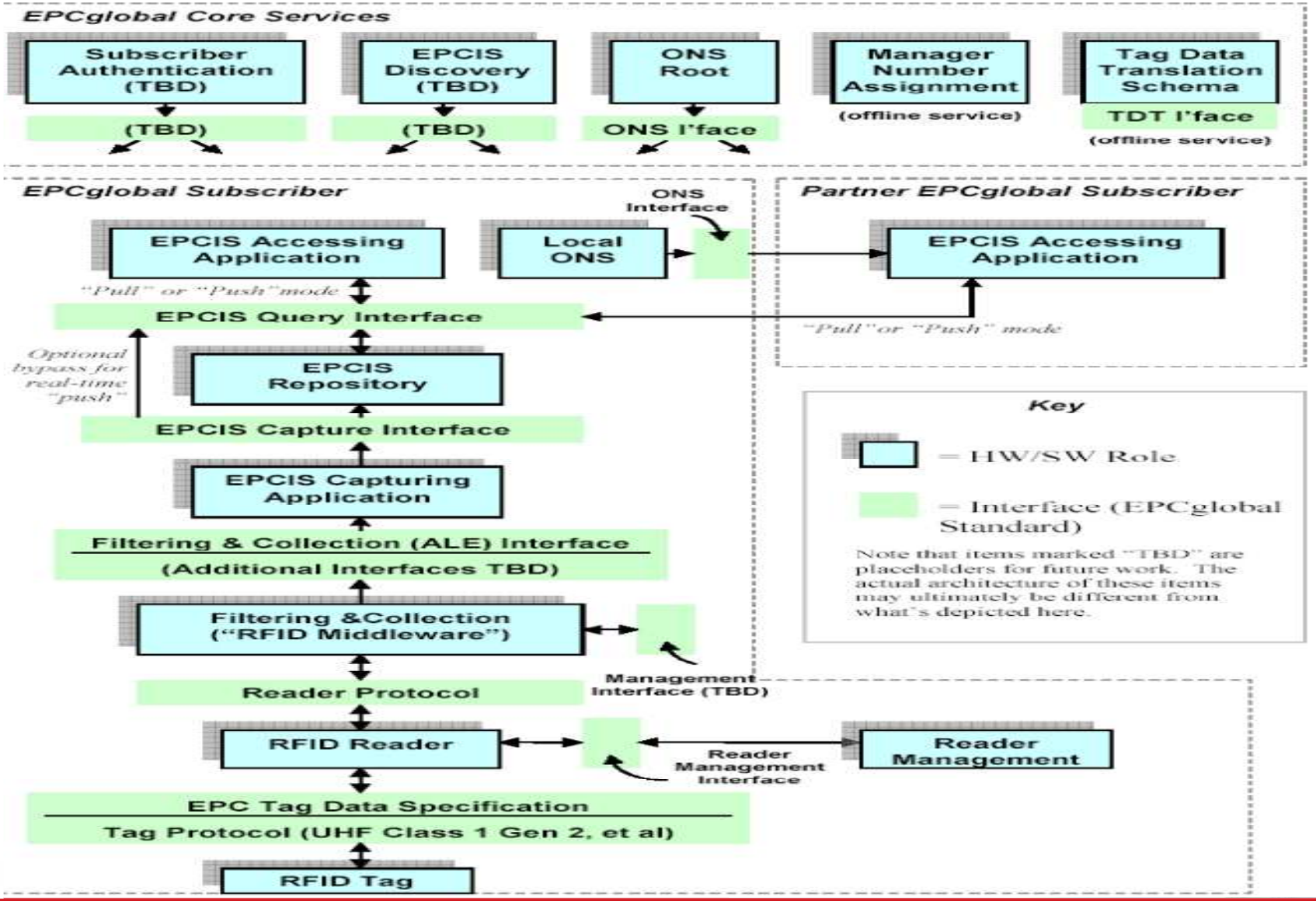
Data Flow Relationships – Intra-Enterprise (1)



Data Flow Relationships – Intra-Enterprise (2)

- The Reader Protocol Interface insulates the higher layers from knowing what reader makes/models have been chosen
- 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
- 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

Roles and Interfaces – Reference



References – Additional Reading

- The EPCglobal Architecture Framework Version 1.3, EPCglobal, March 2009, available online at http://www.epcglobalinc.org/standards/architecture/
- EPC Tag Data Specification 1.1, EPCglobal, November 2003, available online at http://www.epcglobalinc.org/standards/tds/