



Auto-ID: Technology Building Blocks

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AUTO-ID TECHNOLOGY BUILDING BLOCKS

- Uniquely identifying items
 - EPC – Electronic Product Code
- Detecting the presence and identity of items
 - RFID tags & readers
- Representing item characteristics and movements
 - PML – Physical Markup Language
 - ONS – Object Name Service
- Passing the information across the network
 - Savant
- Interpreting and acting on the information
 - Control



AUTO-ID TECHNOLOGY

BUILDING BLOCKS: 1

- Uniquely identifying items
 - EPC – Electronic Product Code



ELECTRONIC PRODUCT CODE: EPC

- EPC is a naming scheme for objects
 - Unique identifier for every object – includes serial number
 - Designed to be scaleable & extensible
- Decouple identity from data
 - Only store the EPC on an item
 - Additional information is held in a database and can be accessed using the EPC as a key
- Global, open standard
 - UCC/EAN support



EPC: 96-BIT VERSION

01.0000A89.00016F.000169D<0

Header
0-7 bits

EPC Manager
8-35 bits

Object Class
36-59 bits

Serial Number
60-95 bits



Version 8 bits

Manufacturer 28 bits
(> 268 Million)

Product 24 bits
(> 16 million)

Serial Number 36 bits
(> 68 billion)



AUTO-ID TECHNOLOGY

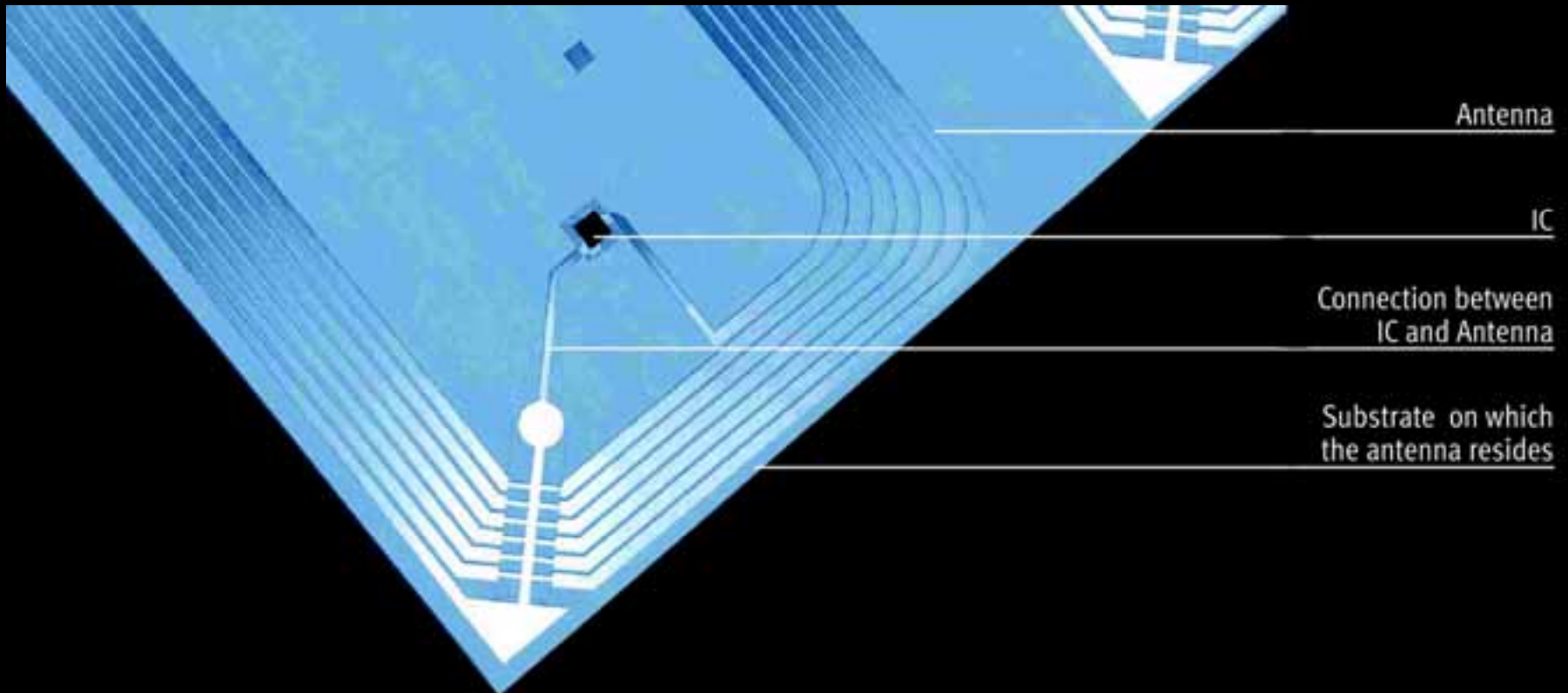
BUILDING BLOCKS: 2

- Detecting the presence and identity of items
RFID tags & readers



RFID TAGS AND READERS

- Tag = substrate + chip + antenna
- Reader = case + electronics + power supply + antenna





RFID TAGS AND READERS

- Operation

 - EPC stored on the tag is sent to the reader

 - Tag is passive – all its power comes from the reader

 - Uses radio waves – non line-of-sight technology

 - Readers are network-direct

- Performance

 - Readily supports the amount of data needed

 - Typical range is tens of cm to ten metres

 - Typical rate is 100-1000 tags per second

 - Must be inexpensive

 - Tags less than 5c

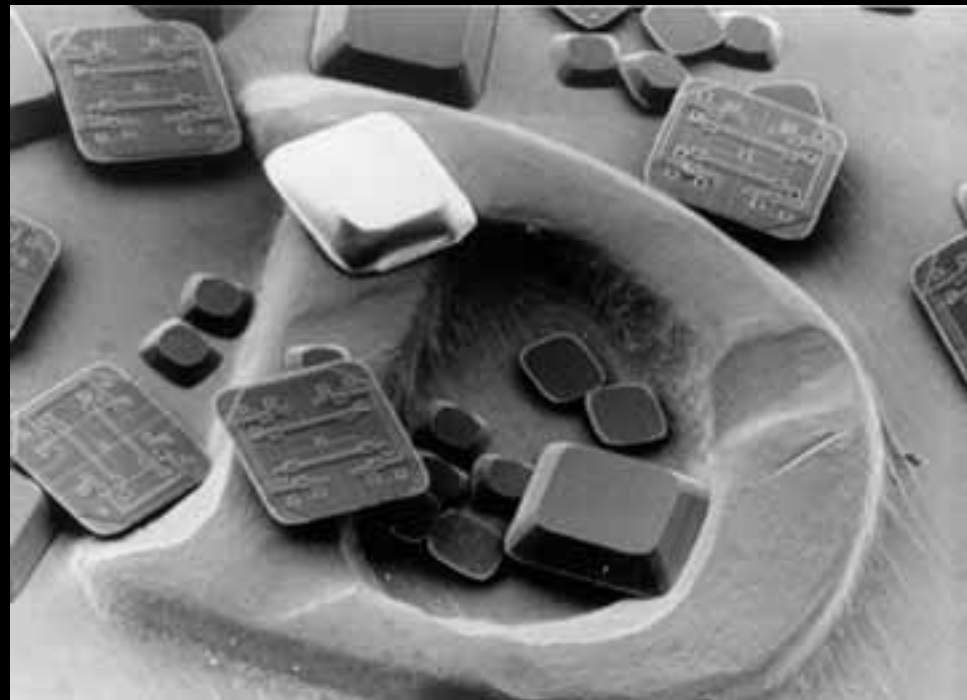
 - Reader target of US\$100



RFID TAG MANUFACTURE



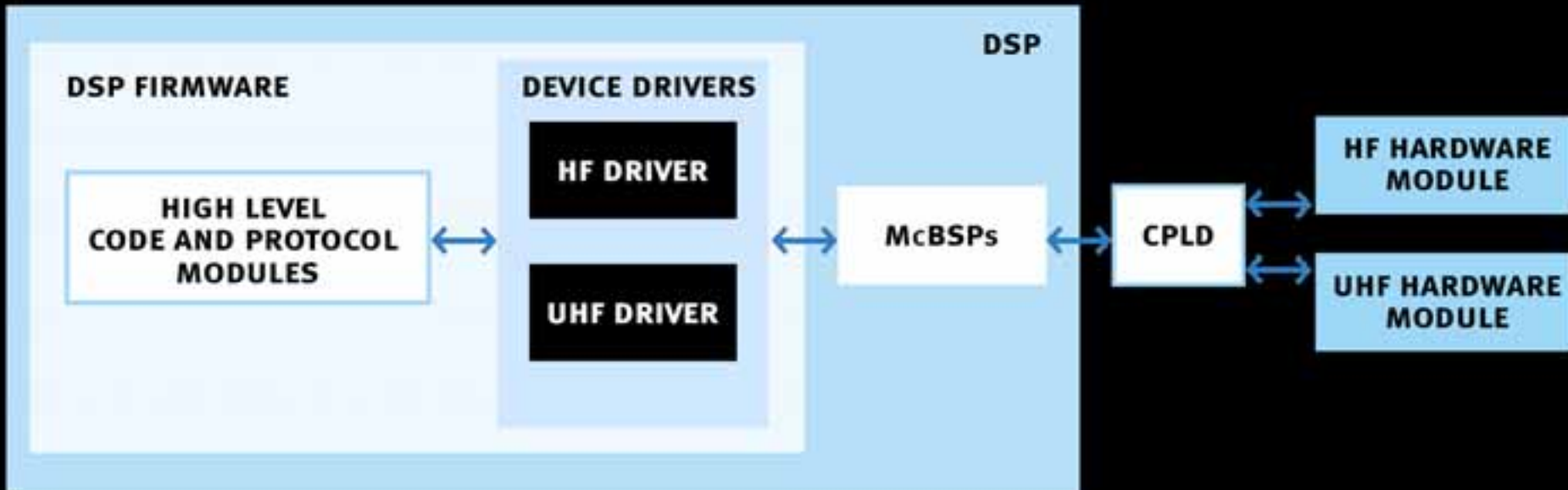
- 5c target for next year or two
1c per process step...
- FSA, printable antennas,
capacitive coupling, roll-to-roll...
- Maybe 1-2c possible in future
- Volumes of $\geq 10\text{bn}$ tags pa
- Chicken-and-egg problem





AGILE RFID READER OPERATION

- Need to support different frequencies
- Different band modules for RF front-end
- CPLD and DSP implement as much as possible
 ‘software’ radio allows re-use of hardware
- Use commodity components wherever possible





AUTO-ID TECHNOLOGY

BUILDING BLOCKS: 3

- Representing item characteristics and movements
 - PML – Physical Markup Language
 - ONS – Object Name Service



PHYSICAL MARKUP LANGUAGE, PML

- Language for describing physical objects – classification and categorisation
describing events, operations etc.

```
<?xml version="1.0" encoding="UTF-8"?>
<BatchOrder>
  <Owner>
    <Role> manufacturer </Role>
    <Entity> Tesco </Entity>
  </Owner>
  <Date label="deliverby">0</Date>

  <Future>
    <Config label="c1">
      <Msr q="1">3</Msr>
      <Price>70</Price>
      <Date label="edited">1038334977000</Date>
      <Part label="box" epc="0000000A1000002000000000">
        <Part label="item1" epc="00000000100000A000000000"/>
        <Part label="item2" epc="00000000100000B000000000"/>
        <Part label="item3" epc="00000000100000D000000000"/>
      </Part>
    </Config>
  </Future>
  <Present>
    <Config label="c1">
      <Part label="box" epc="0000000A1000002000000005">
```

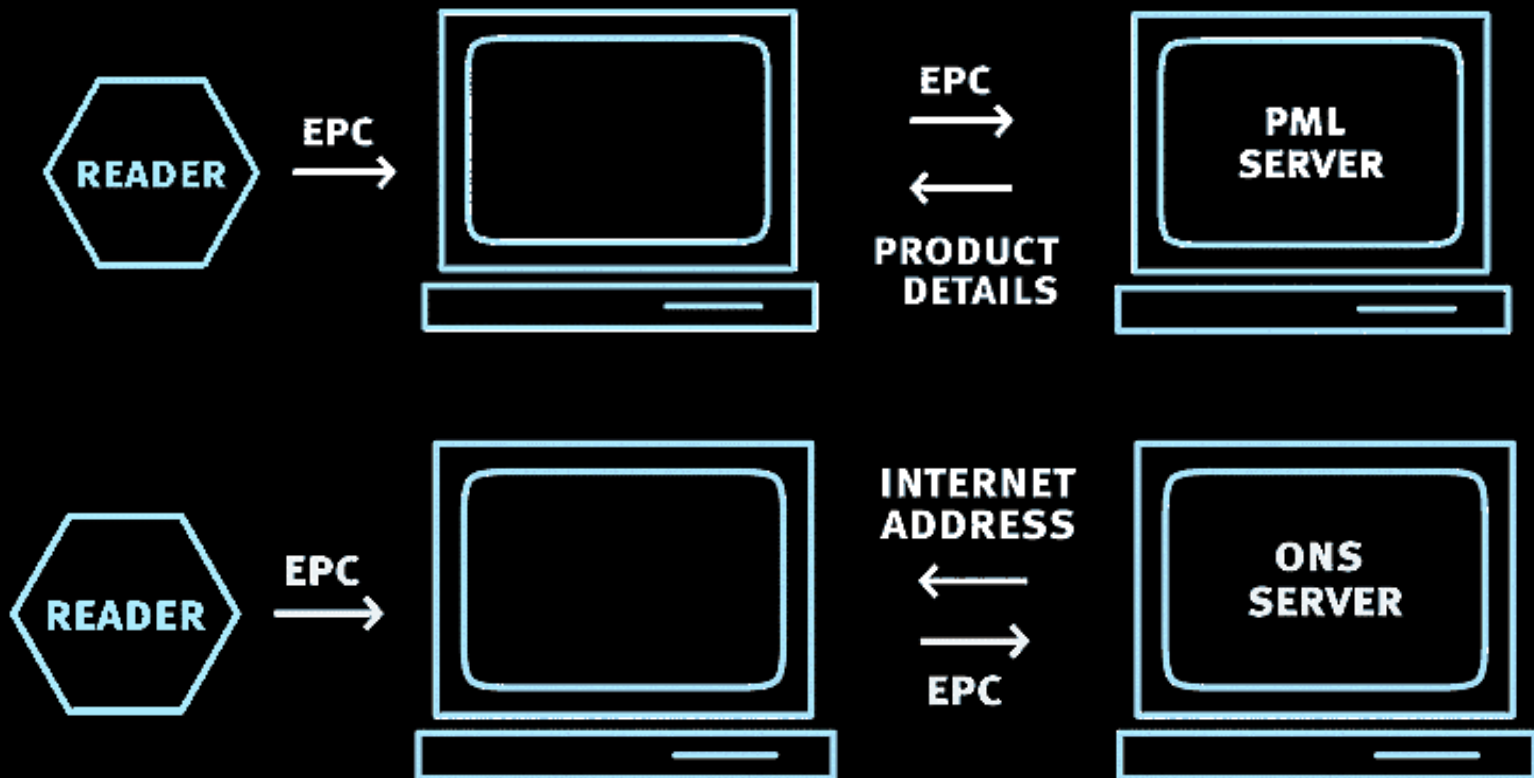
```
<?xml version="1.0"?>
<PML VERSION="0.10">
  <READ EPC="00000000B000001000000002">
    <DATE LABEL="QUERY">74259682207</DATE>
  </READ>
  <READ EPC="00000000B000001000000001">
    <DATE LABEL="QUERY">74259682207</DATE>
    <EPC>0000000000000000000000018</EPC>
  </READ>
</PML>
```



PML SERVER AND OBJECT NAME SERVICE, ONS

- PML server
network database

- ONS server
redirection service – a telephone book
based upon Domain Name Service (DNS)





AUTO-ID TECHNOLOGY

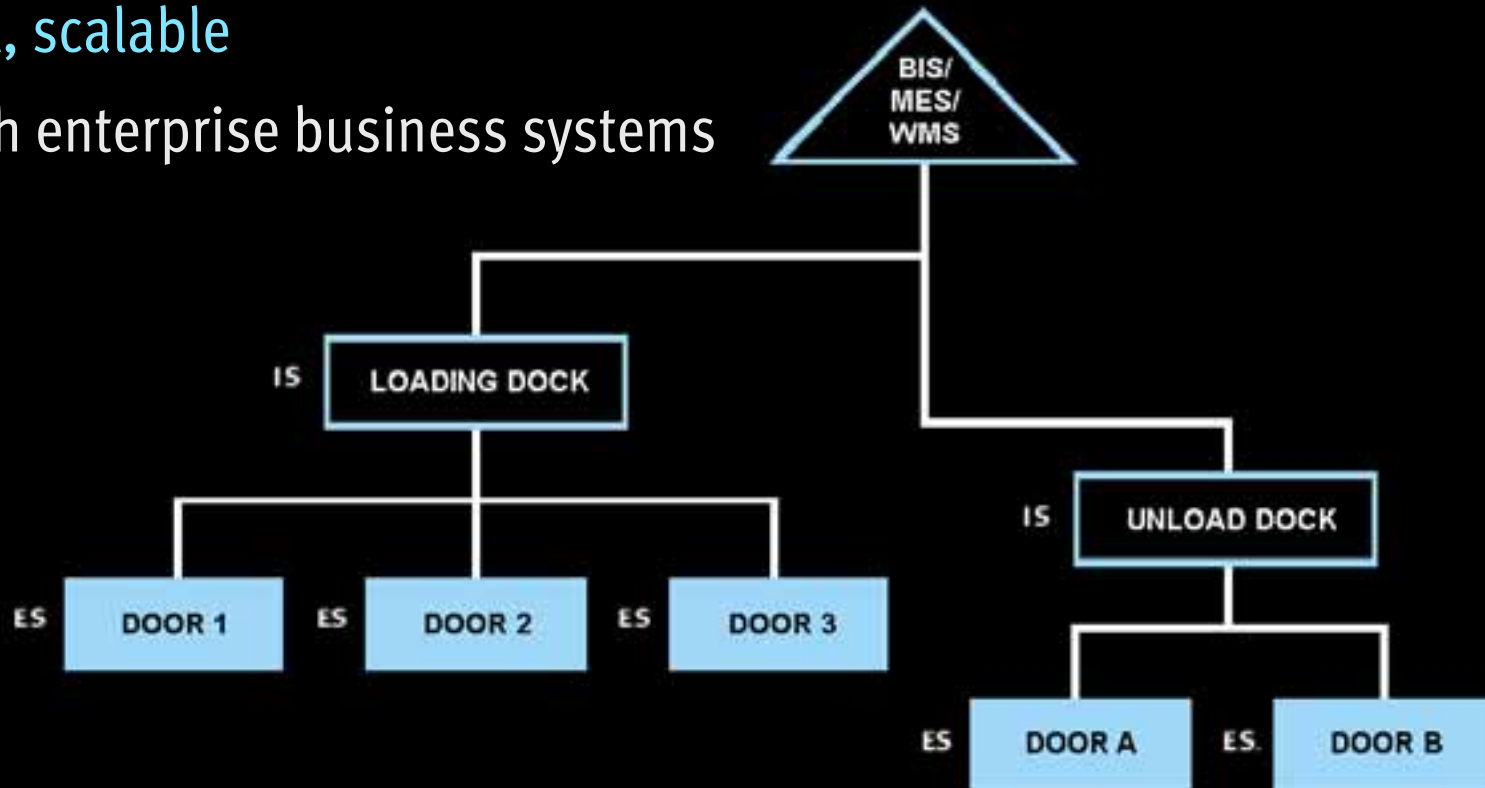
BUILDING BLOCKS: 4

- Passing the information across the network
Savant



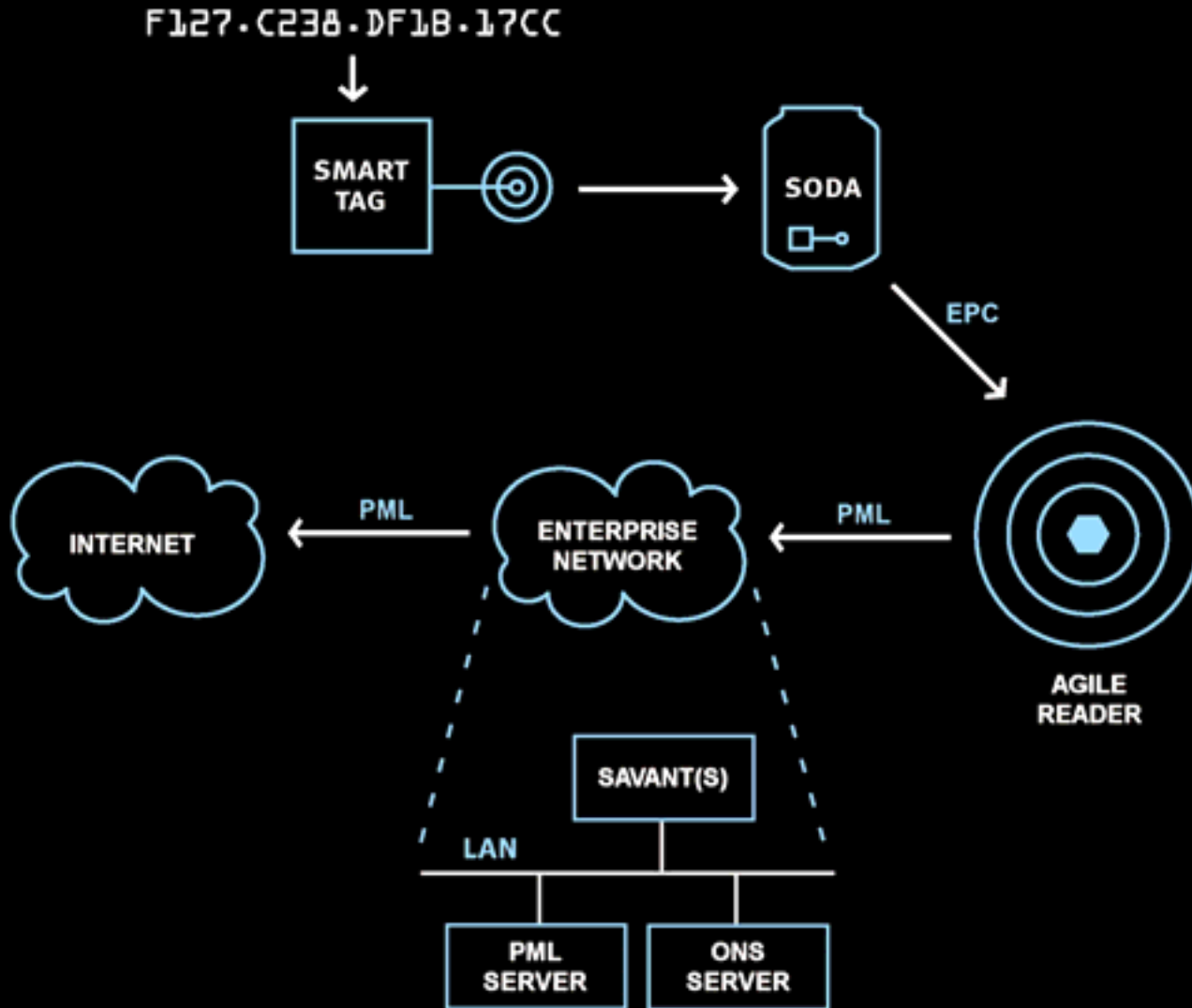
SAVANT

- System building block for data management
designed to deal with copious amounts of data
performs local filtering/processing and caching/storage
hierarchical, scalable
- Interface with enterprise business systems





AUTO-ID TECHNOLOGY RECAP



...smart, scalable
networking for the
physical world



AUTO-ID CENTRE MOTIVATION RECAP

- Some way of automatic, reliable transfer and update of information based on physical operations
- One single system for the whole supply chain



WHY DEVELOP AUTO-ID BASED SYSTEMS?

- Auto-ID data is:
 - Accurate
 - Fine-grained
 - Item-level
 - Complete
 - Automatic
 - Timely
 - Universal
- In supply-chain terms, this means:
 - Accurate knowledge of what is where
 - Reduced safety stock levels
 - Increased on-shelf availability
 - Faster monitoring of demand
 - Quicker analysis of business operation
 - Better traceability for recalls
 - Less opportunity for theft
 - Reduced diversion of goods
 - Better traceability of black/grey markets
 - True interoperability



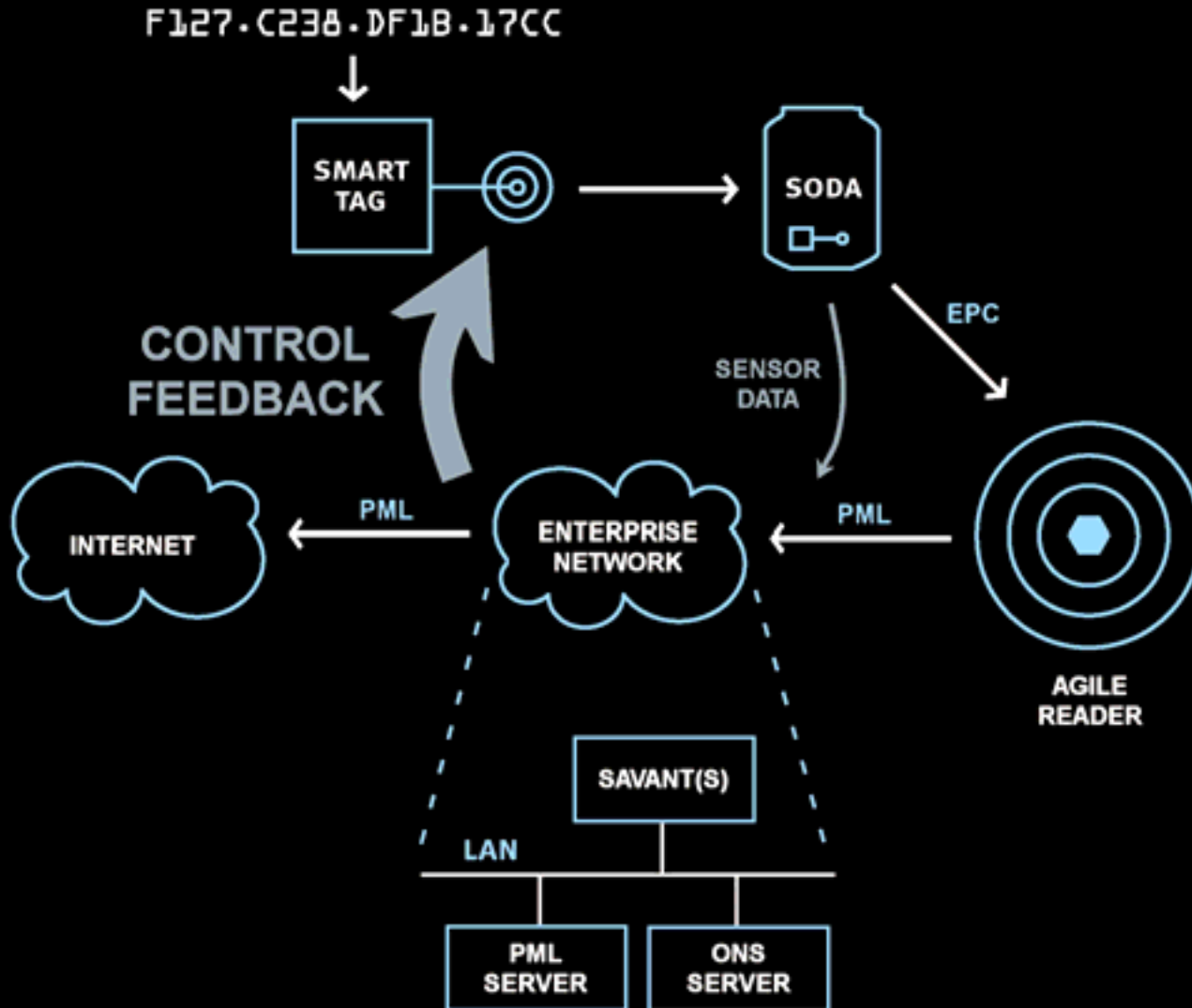
AUTO-ID TECHNOLOGY

BUILDING BLOCKS: 5

- Interpreting and acting on the information
Control



AUTO-ID FOR CONTROL



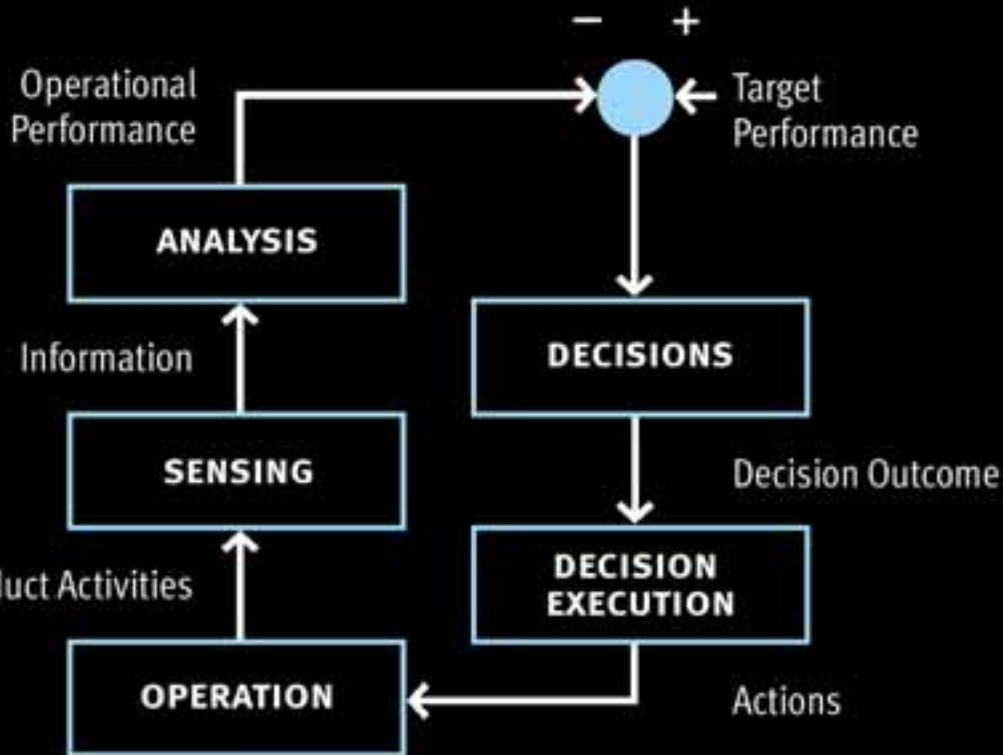


WHY DEVELOP AUTO-ID BASED CONTROL?

- Auto-ID data is:
 - Accurate
 - Fine-grained
 - Item-level
 - Complete
 - Automatic
 - Timely
 - Universal
- In control terms, this means:
 - Reliable operation
 - Good performance
 - Ability to capture item level preferences
 - Support for customised control
 - Interoperability



SIMPLE THERMOSTATIC HEATING CONTROL



- Operation – room heating
- Sensing – thermostat
- Analysis – calculate temperature, compare with thresholds
- Decision – out of range?
- Execution – adjust gas valve



AUTOMATED RETAIL SHELF MANAGEMENT



- Operation – having products available on shelves
- Sensing – stock levels, removal rates, POS data
- Decision – replenishment & reordering planning, theft detection
- Execution – actioning replenishment & reordering, alerting security



FLEXIBLE CONTROL OF A DISTRIBUTION FLEET



- Operation – delivering food products to retail outlets
- Sensing – product load & condition, truck location
- Decision – (re)scheduling, planning rerouting
- Execution – redirecting individual vehicles to new targets



MASS CUSTOMISATION IN MANUFACTURING



- Operation – gift box packing
- Sensing – item, box type and location
- Decision – customer order content, priorities, quality assurance
- Execution – adaptive automated materials handling



VIDEO



AUTO-ID: MERGING BITS AND ATOMS

- Motivation
- Background
- Technology building blocks
- Auto-ID for manufacturing
- Questions

