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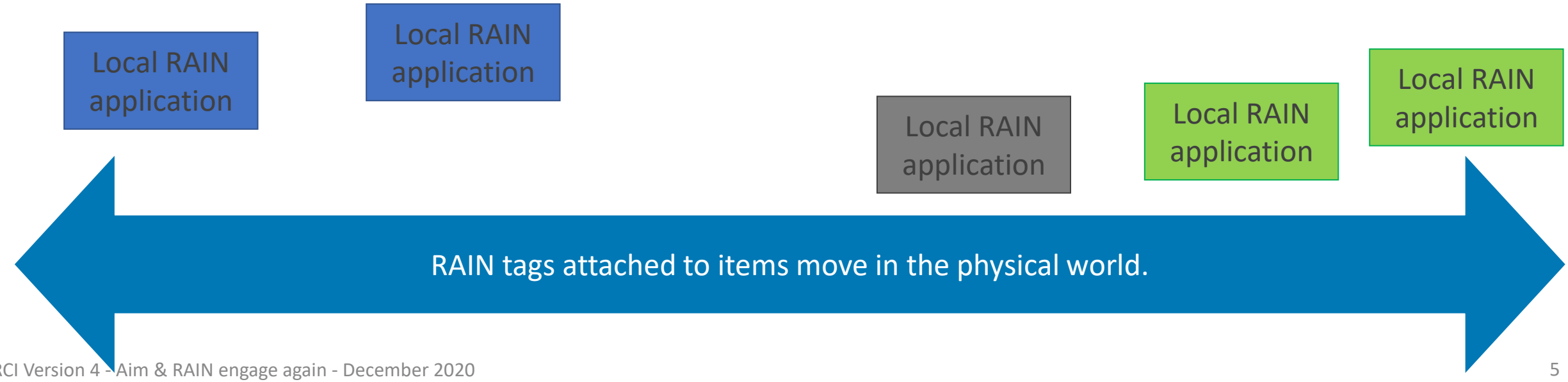
RAIN RCI Version 4

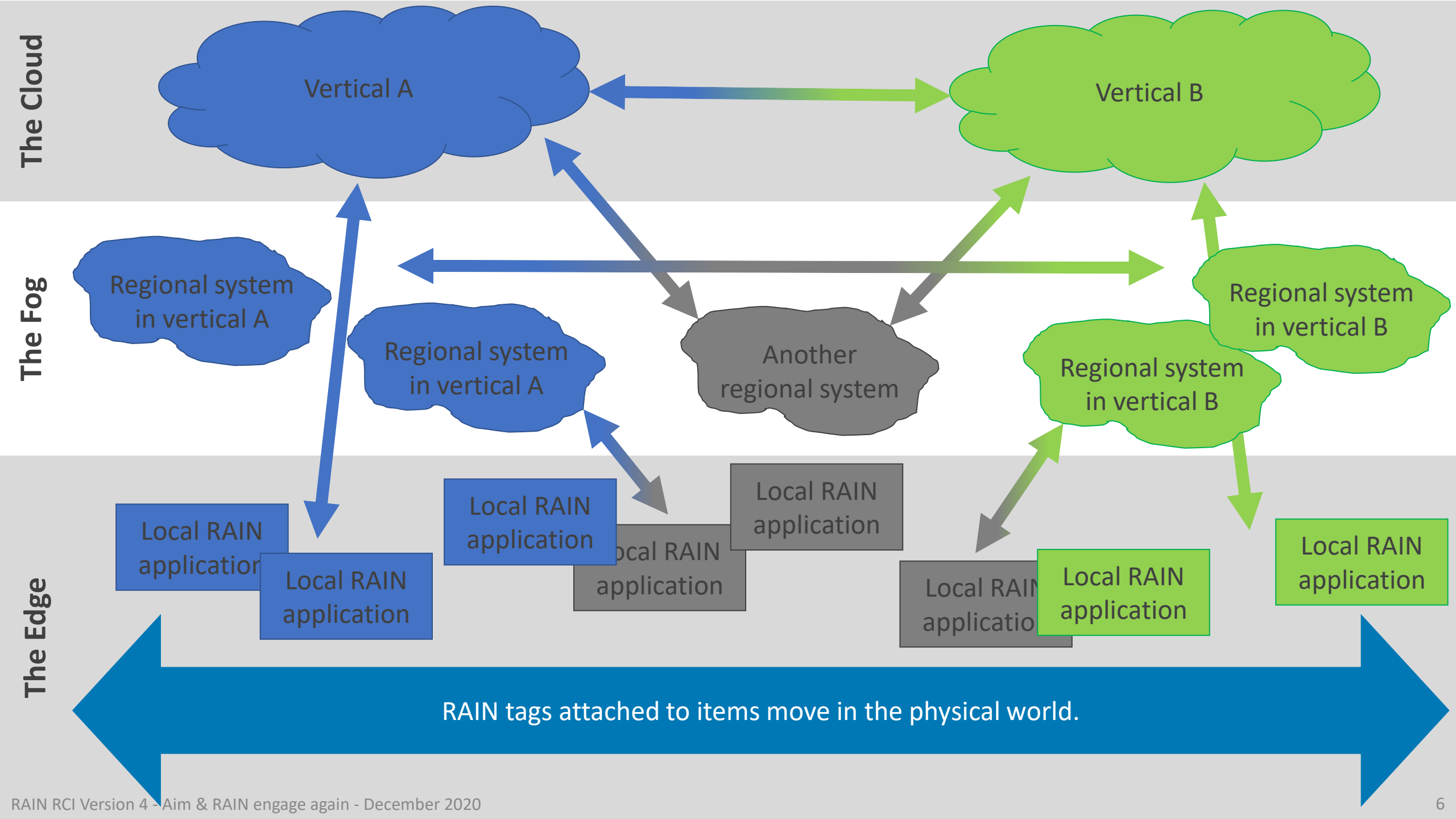
regulations, tag filters, crypto and sensors

Bertus Pretorius – apretorius@licensys.com
(Co-chair RAIN Developers Group)

Increasingly RAIN RFID links the physical world with the digital world.

In future RAIN tags will be everywhere.




The Cloud
The Fog
The Edge
Vertical A
Vertical B
Regional system in vertical A
Regional system in vertical A
Another regional system
Regional system in vertical B
Regional system in vertical B
Local RAIN application
Local RAIN application
Local RAIN application
Local RAIN application
Local RAIN application
Local RAIN application
Local RAIN application
RAIN tags attached to items move in the physical world.

Synopsis

Acid RAIN and RAIN flooding are topical.

Key players are realising that RAIN is more than just a barcode or an item number (“an EPC”).

- GS1 has a work group on digital signatures and is investigating how to add item information to EPCs.
- Many RAIN sensor applications are announced.
- Tag data security is prominent in counterfeit discussions.
- RAIN enabled blockchains are announced to solve complex problems.

This talk will show how the RAIN Reader Communication Interface (RCI) already supports, in a standard and interoperable way, most of the features for current and future needs.

The aim is to arm integrators and business leaders with the knowledge to benefit fully from RAIN.

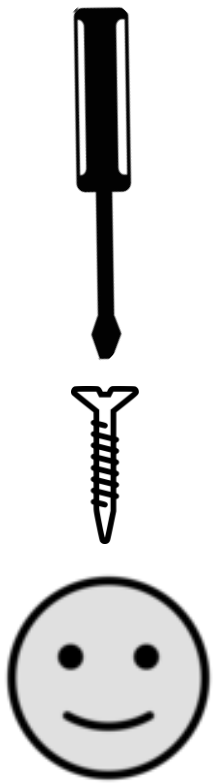
RAIN RCI is at the same time a guide and a specification for reader vendors, integrators and RAIN service architects.

The joys of fasteners!

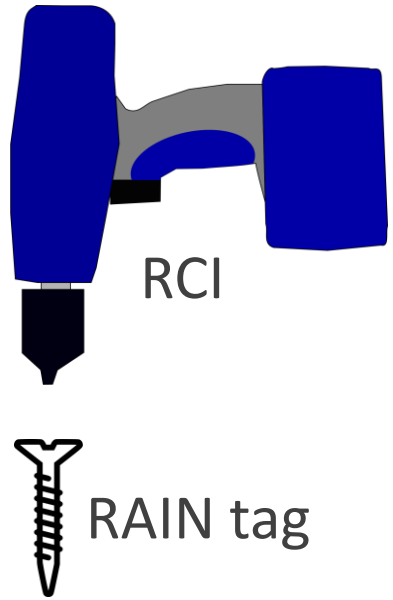
Using the wrong tool is inefficient and frustrating.

The joys of fasteners!

Using the wrong tool is inefficient and frustrating.



Using the right tool gets the job done.

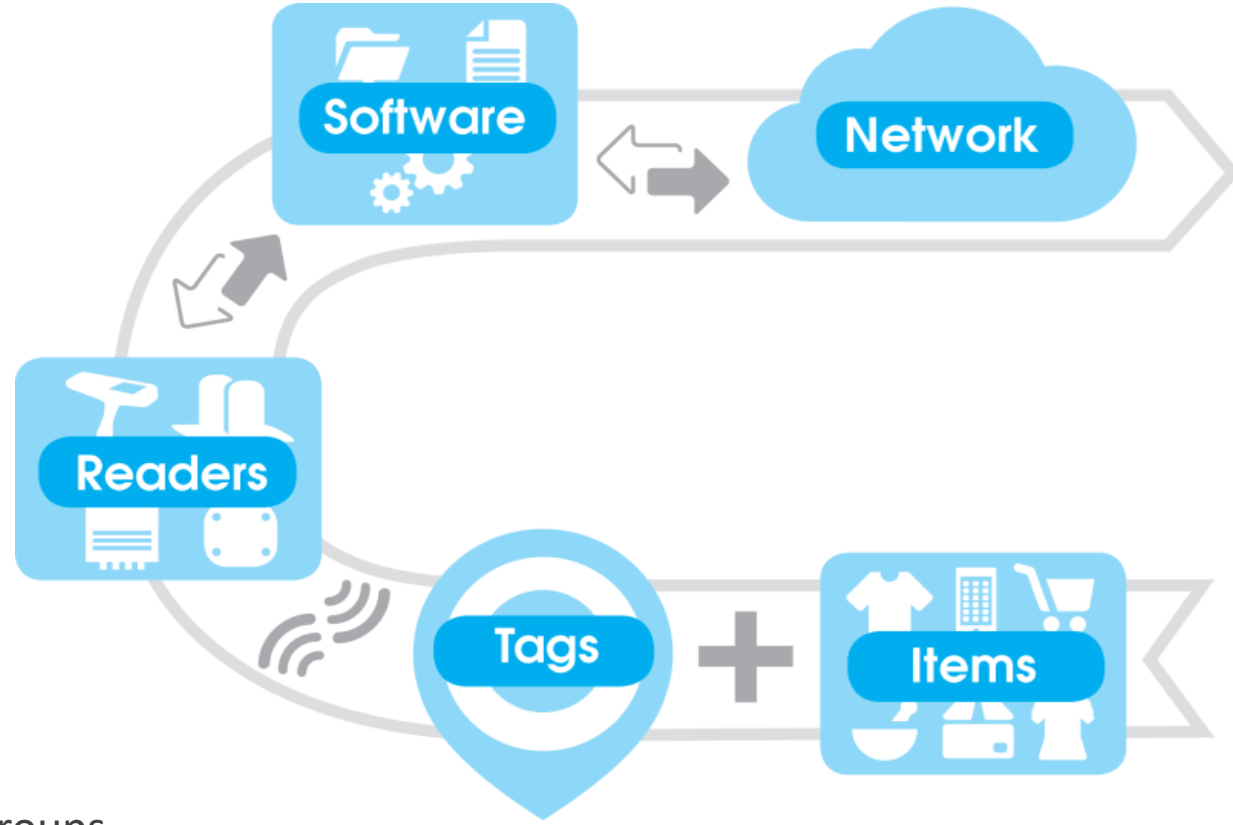


Using the perfect tool makes life a pleasure.

RAIN RCI is the perfect tool.

Agenda

- The RAIN RCI principles
- RAIN interference
- RAIN tag memory
- “Reading” a RAIN tag
- Sensors
- Crypto
- RCI Version 5
- A list of very useful RAIN publications and workgroups



Scott McMillan will show RAIN RCI in action in this room C at 2:10 PM.

Scott is both an GS1 LLRP and RAIN RCI expert.

Josef Preishuber-Pflügl will follow Scott with regulations details, especially the EU in this room at 3:30 PM.

Joe, besides being the RAIN regulations expert, is the chair of the RAIN Technical WG and convenor of the ISO/IEC WG responsible for the standardisation of the RAIN air protocol.

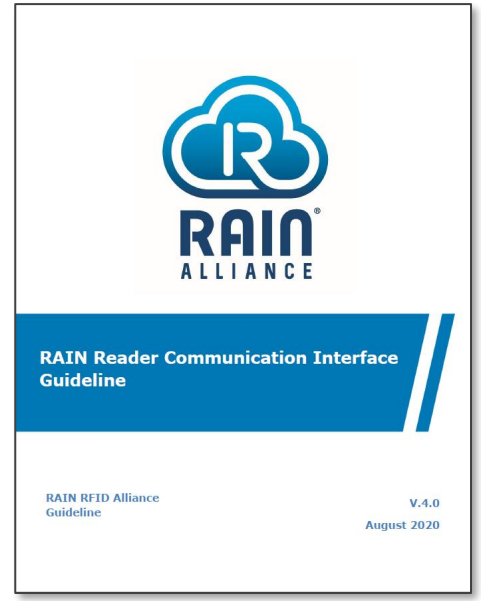
RCI principles

RCI is an intelligent tool, like a bread-maker, a label-stamper, a cabinet-folder;
you set it up and then you let it do the job, no micro-management, no APIs.

Reader vendors should deal with the air protocol, it is an expert job,
allowing data-owners and integrators to focus on the use of data and the readers.

- The configuration is schema-based using JSON field name-value pairs.
- All fields have defaults with most fields optional.

RCI therefore works for simple readers, and for complex readers.



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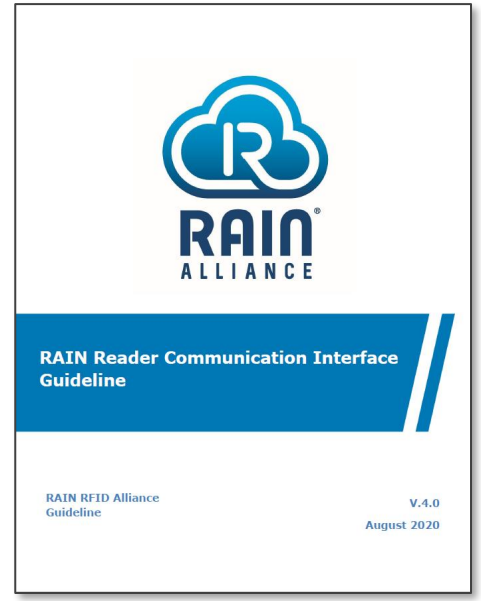
RCI, by design, hides the complex details of the air protocol.

- The application instructs the reader, using RCI, for a specific outcome.
- The reader uses the air protocol to achieve that outcome.
- The reader reports the outcome – the result of an INVENTORY and optional ACCESS of tags of interest.



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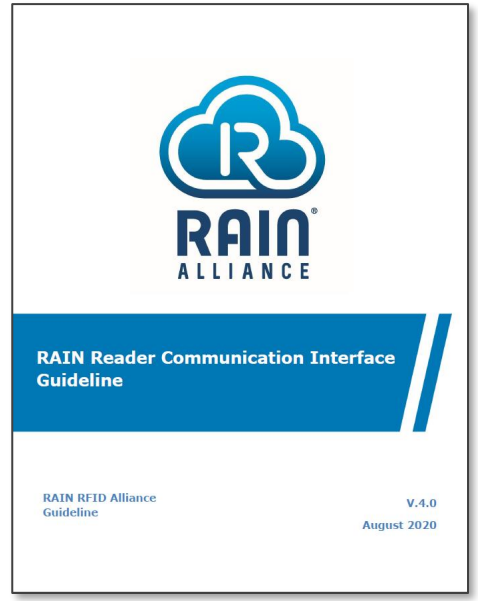

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RCI performs its duties at the hand of 3 task profiles:

- The RF profile instructs the reader on the Regulatory environment and the expected tag types and population.
- The ReadZone profile instructs the reader how to form the ReadZone by defining the operations of the antennas.
- A SpotProfile instructs the reader which tags it must INVENTORY, what additional ACCESS is to be performed and how to report it.

RAIN interference

RAIN interference will cause RAIN enabled applications to fail.

- On the RF level
  - Other RF systems interfere with RAIN
  - RAIN interferes with other systems
  - Tag crosstalk
  - Reader crosstalk

- On the tag level
  - RAIN flooding
  - Acid RAIN

- On the reader interface level

- On the people level

RCI handling of interference

RAIN guidelines

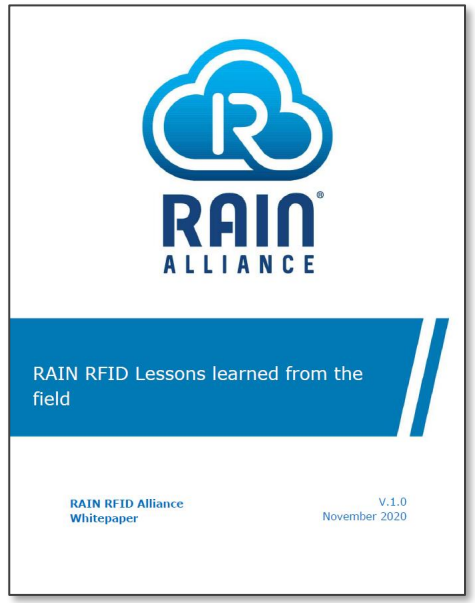
System Design Guidelines – Air Interface and Protocol Considerations details

- The best settings for a range of Regulatory environments.
- Expert RF settings for special ReadZone performance requirements.

RCI implements these settings.

- *Lessons learned from the field* discusses various bad practices and remedies.

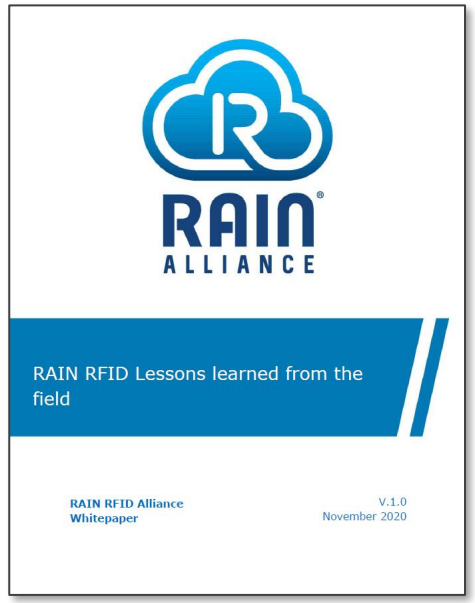
RCI enables these best practices.



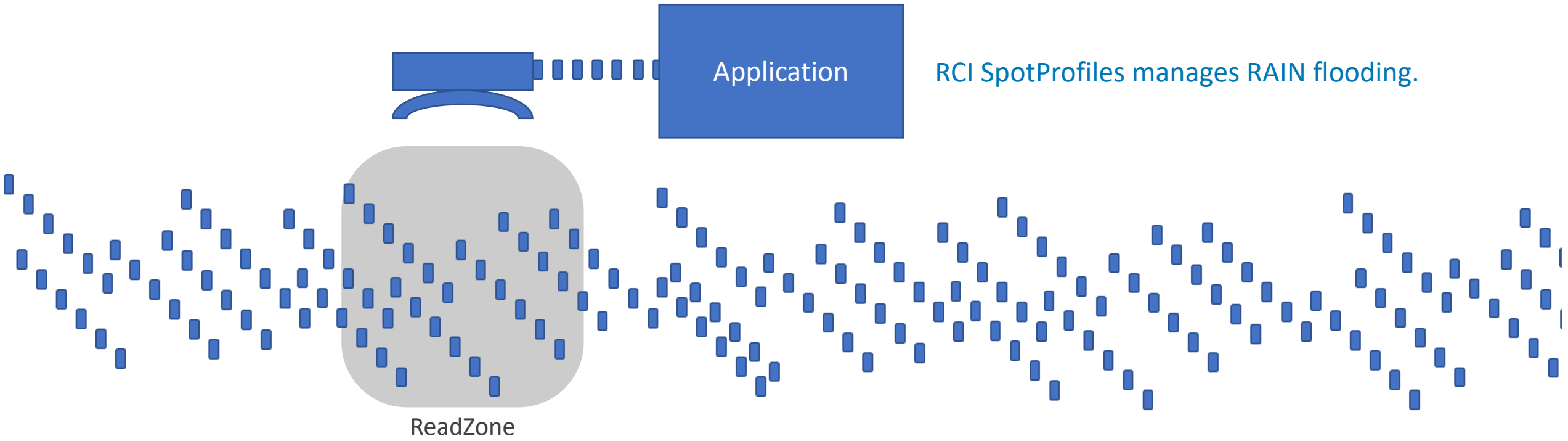
RCI handling of RF interference

RCI methods

- RAIN RCI regulatory controls:
  - General: AirProtSet, FreqRegSet, RF configuration, default power
  - Mode: Auto detect, Dense Reader, High Data Rates and Monitor
  - TargetTags:
    - SIMPLE (only inventory), READ (additional access), WRITE
    - Passive sensors: ALARMSENSOR, SNAPSHOTSENSOR
    - BAP (battery assisted)
    - Active sensors: SIMPLESENSOR, FULLSENSOR
    - CRYPTO.
- ReadZone construction: A ReadZone is constructed as a set of coordinated antennas with
  - ReadZone power settings, start, stop and duty cycle conditions incorporating triggers.
  - Individual antenna power settings and duty cycles.

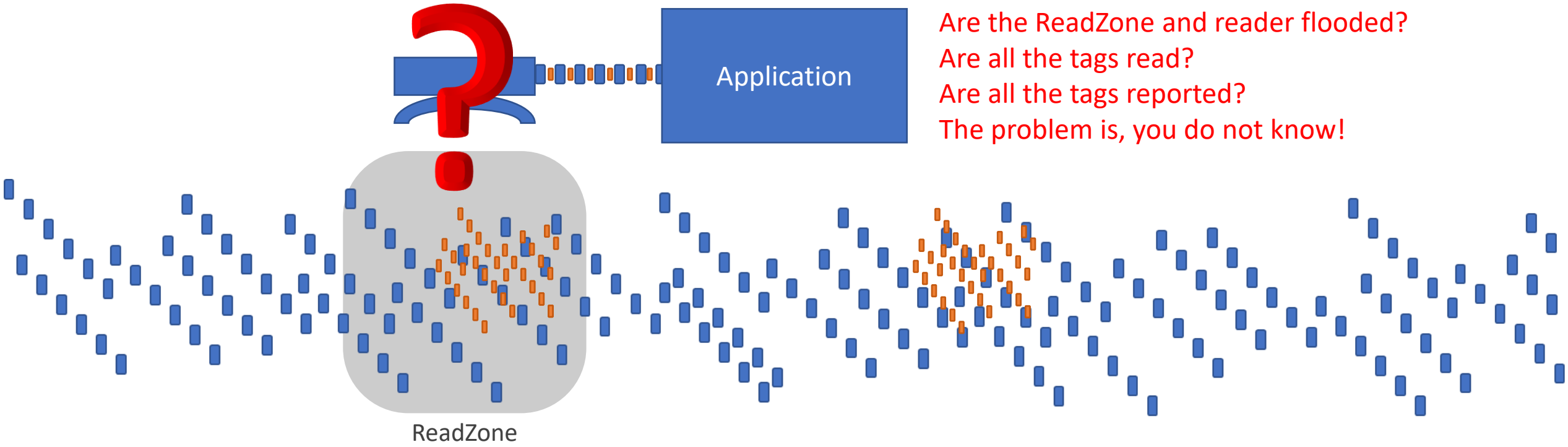


RAIN flooding – Interference by RAIN success



RCI SpotProfiles manages RAIN flooding.

RAIN flooding – Interference by RAIN success



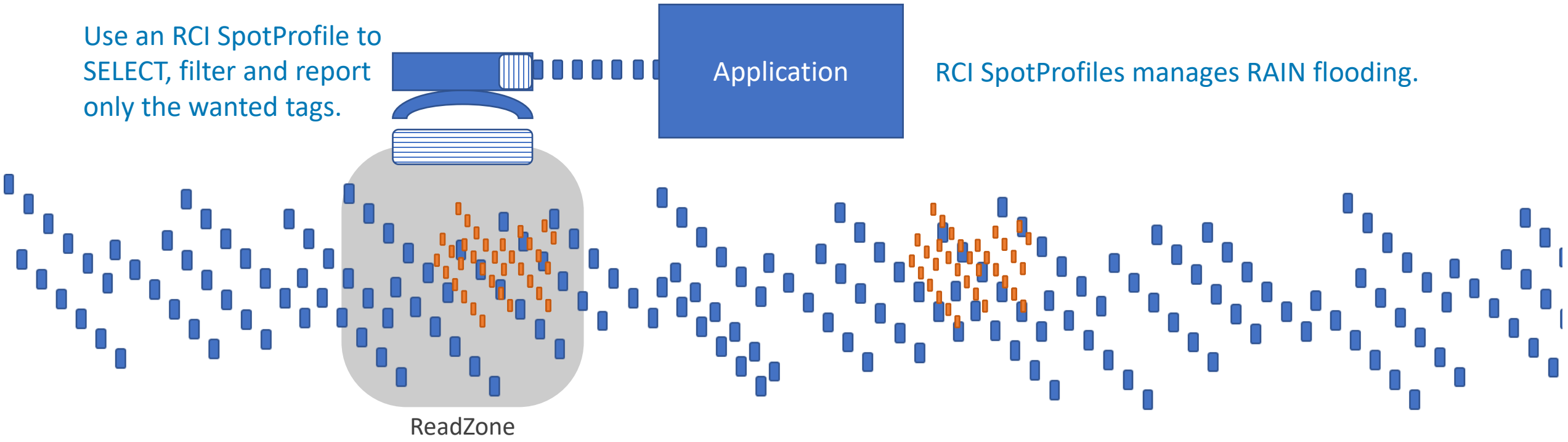
Are the ReadZone and reader flooded?
Are all the tags read?
Are all the tags reported?
The problem is, you do not know!

Parcel routing tags

Tags on items inside some parcels

RAIN flooding – Interference by RAIN success

Use an RCI SpotProfile to SELECT, filter and report only the wanted tags.



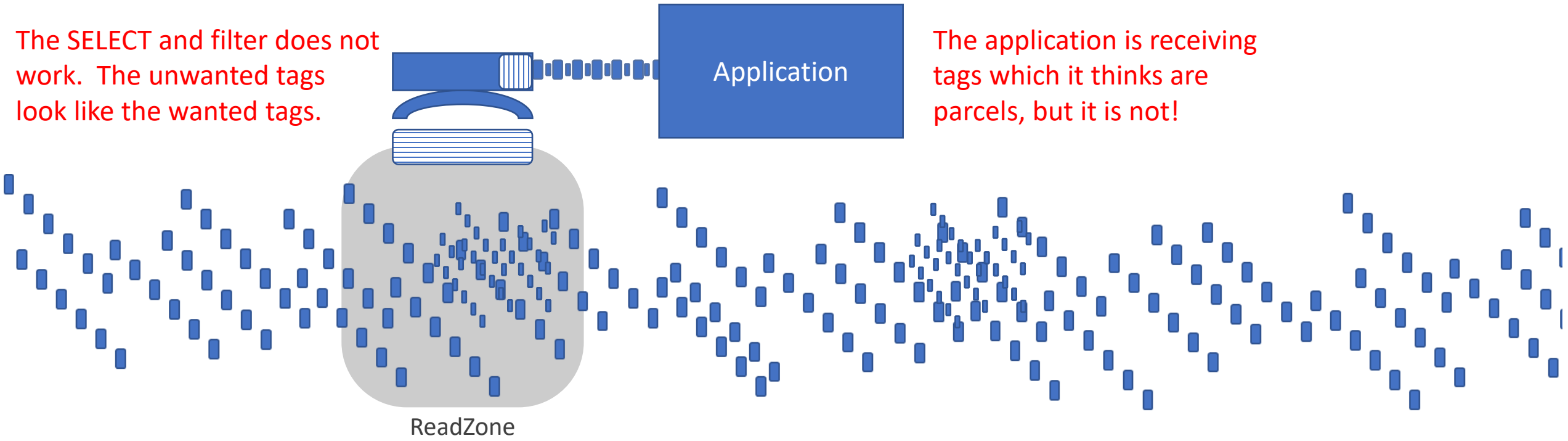
RCI SpotProfiles manages RAIN flooding.

Parcel routing tags

Tags on items inside some parcels

Acid RAIN – Interference by bad tag data

The SELECT and filter does not work. The unwanted tags look like the wanted tags.



The application is receiving tags which it thinks are parcels, but it is not!

- Parcel routing tags
- Tags on items inside some parcels which look like parcel tags

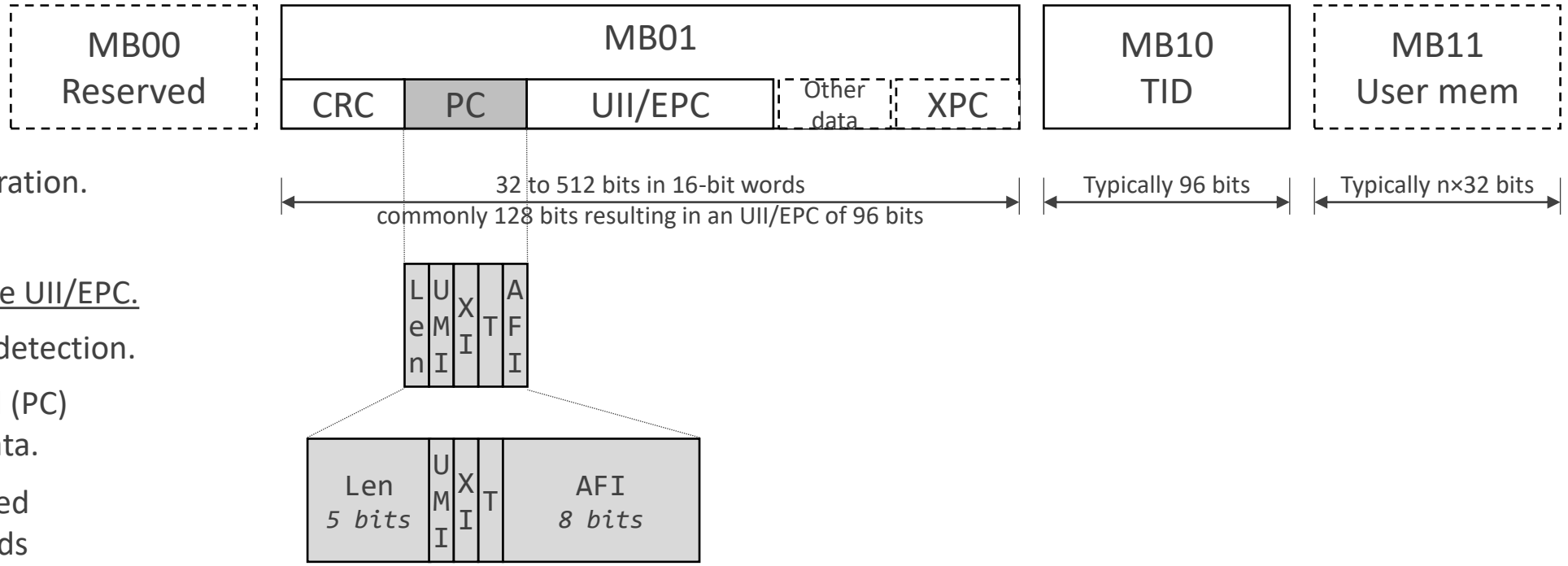
We can only deal with acid RAIN and RAIN flooding when we program the tags properly.

Tag memory

MB01 and MB10 are compulsory.

MB11 is optional.

MB00 is used for tag configuration.

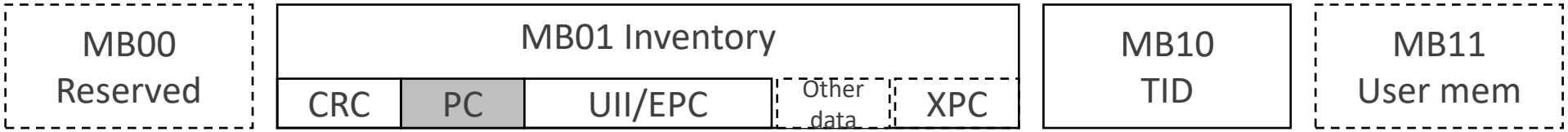


<u>MB01 contains more than the UII/EPC.</u>

- The 16-bit CRC is for error detection.
- The 16-bit Protocol Control (PC) word informs on the tag data.
- The optional 16-bit Extended Protocol Control (XPC) words provide item and sensor data.
- MB01 may also contain other data.

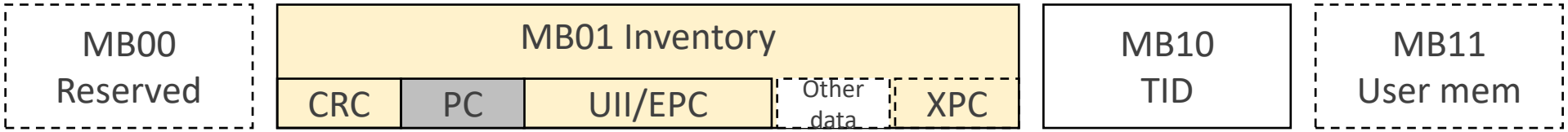
Len: UII/EPC 16-bit word length (0 to 496 bits)
UMI: User memory indicator
XI: XPC indicator
T: Standard toggle bit 0 → GS1 (EPC) and 1 → ISO + AFI (UII)
AFI: Application Family Identifier used by ISO to indicate the type of UII

Reading a tag



SELECT: The operation of choosing a tag population for inventory and access.
└—INVENTORY: The operation of identifying tags using UII/EPC.
└—ACCESS: The operation of communicating with (reading from and writing to) a tag.

Reading a tag



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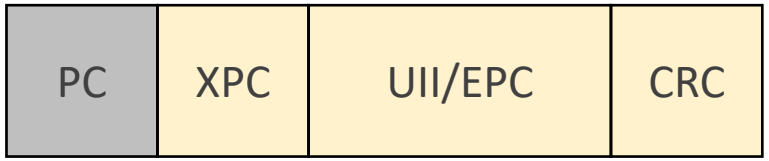
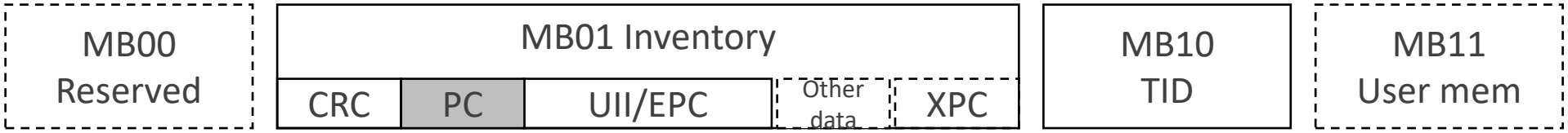
During INVENTORY the tag reports these bits from MB01.

If XPC words exist on the tag, then the tag reports it following the PC word.



NOTE: During INVENTORY the tag reports the stored bits of MB01 in a different order.

Reading a tag



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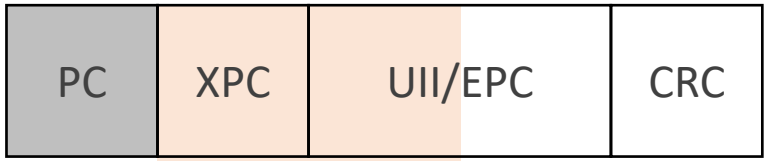
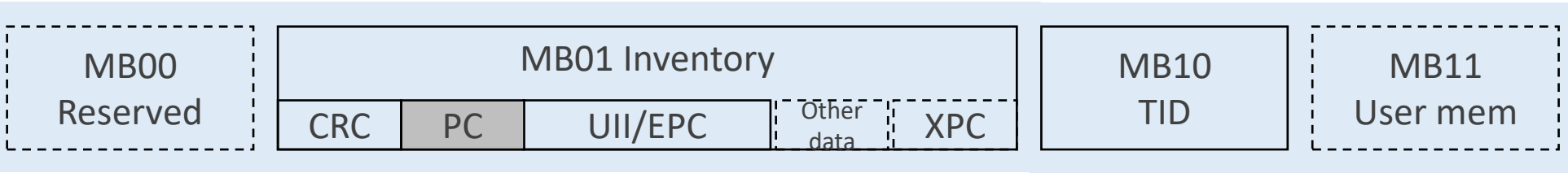


Bad readers report these bits as the UII/EPC

NOTE: During INVENTORY the tag reports the stored bits of MB01 in a different order.

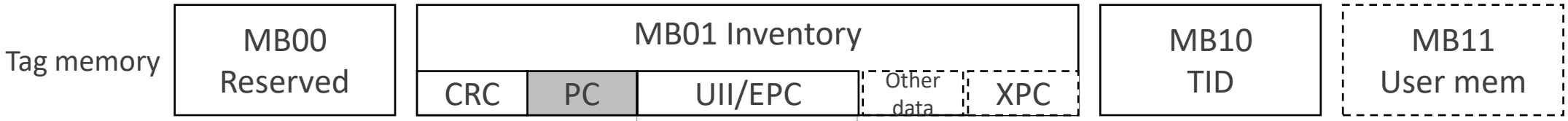
Reading a tag



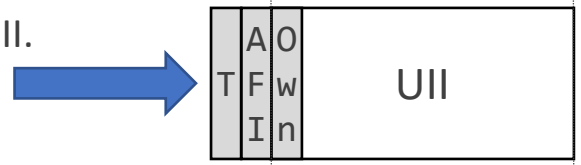
SELECT: The operation of choosing a tag population for inventory and access.
└—INVENTORY: The operation of identifying tags using UII/EPC.
└—ACCESS: The operation of communicating with (reading from and writing to) a tag.

To obtain MB10 and MB11 data a reader must explicitly access it after the tag was INVENTORIED. MB00 and MB01 can also be accessed after INVENTORY.

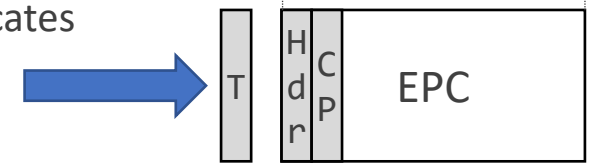
Tag selection and filter



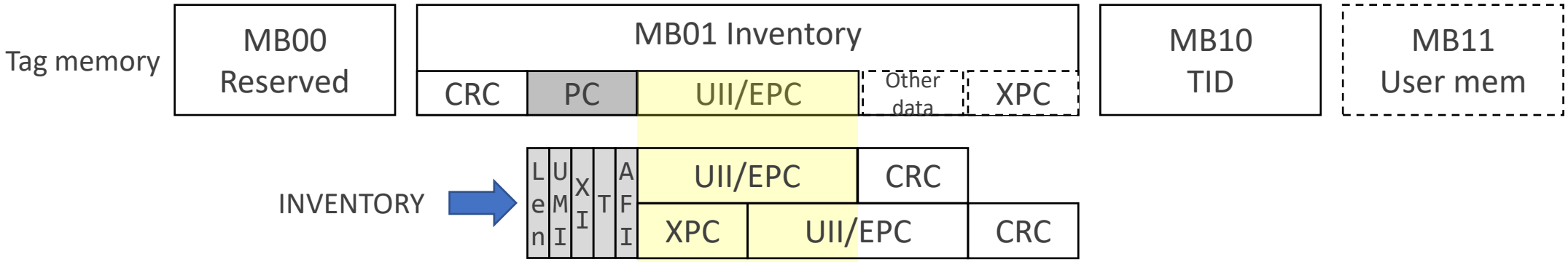
In ISO the owner ID shall be the first field of the UII.
SELECT and filter therefore work on
T || AFI or T || AFI || Own.



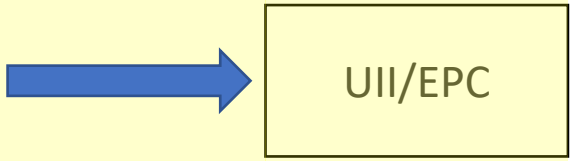
In GS1 the EPC starts with the header which indicates the type of EPC, followed by the company-prefix.
SELECT and filter therefore work on
T || Hdr or T || AFI || CP.



Reader interface interference



Bad readers report only the perceived UII/EPC to the application calling it “the EPC”. Therefore an uninformed person believes tags only have an “EPC”.



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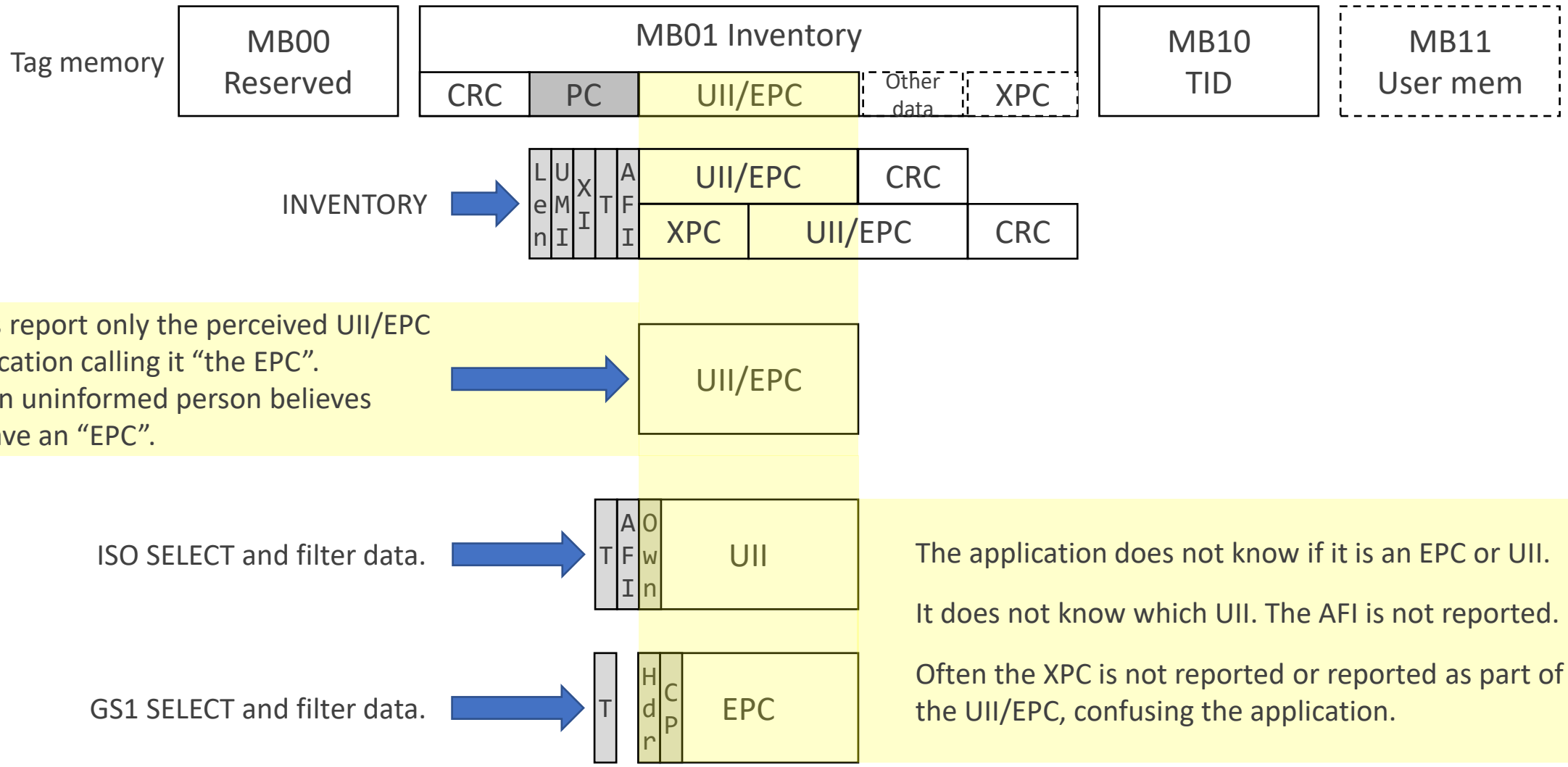


RCI reports tag data properly – examples

ISO INVENTORY only: T=1

```
{"Report":"TagEvent","AFI":":92","UII":":0123:4567:89AB:CDEF:89AB:CDEF"}
{"Report":"TagEvent","AFI":":00","UII-NOT-CONFIGURED":":0123:4567:89AB:CDEF:89AB:CDEF"}
```

AFI=0x01 to 0x07

```
{"Report":"TagEvent","AFI":":03","UII-PROPRIETARY":":0123:4567:89AB:CDEF:89AB:CDEF"}
```

GS1 INVENTORY only: T=0 – EPCs *EPCs are specified by the GS1 Tag Data Standard (TDS)*

Header=0x00

```
{"Report":"TagEvent","Scheme":"UNPROGRAMMED","EPC":":0022:1234:0123:4567:89AB:CDEF"}
```

Header=0x2C to 0x41

```
{"Report":"TagEvent","Scheme":"SGTIN","EPC":":3003:4567:89AB:4567:89AB:CDEF"}
```

Headers 0xE0 and 0xE2

```
{"Report":"TagEvent","Scheme":"TID","EPC":":E203:4567:ABCD:4567:89AB:CDEF"}
```

ISO with MB11 read *This SpotProfile instructs the reporting of the DateTime and PC words.*

```
{"Report":"TagEvent","DT":"2017-09-11T13:06:01.000","Spot":"Seen","InvCnt":25,
 "PC":":3592:0025","AFI":":01","UII-PROPRIETARY":":0123:4567:89AB:CDEF:89AB:CDEF",
 "MB":[{"ID":3,"Start":0,"Data":":2323:2323:2323:2323"}]}
```

RCI data interpretation

A special feature of RCI is to interpret tag data.
EPC and UII interpretation are compulsory since version 3.

Identifier	Specification
TAGUSE	ISO/IEC 18000-63
20248	ISO/IEC 20248
EPC-URI	GS1 TDS
SIMPLESENSOR	ISO/IEC 18000-63
SNAPSHOTSENSOR	ISO/IEC 18000-63

XPC_W1 flag	RCI TagIndicator value
SA (sensor alarm)	"ALARMSENSOR"
SS (simple sensor tag)	"SIMPLESENSOR"
FS (full-function sensor tag)	"FULLSENSOR"
SN (snapshot sensor tag)	"SNAPSHOTSENSOR"
B (battery assisted passive tag)	"BAP"
TN (tag notification)	"TAGNOTE"
U (untraceable)	"UNTRACEABLE"
K (killable)	"KILLABLE"
NR (nonremoveable)	"NONREMOVE"
H (Hazmat)	"HAZMAT"


```
{"Report":"TagEvent","TimeStamp":1571795244.815,
 "AFI":":92","UII":":C098:0B4F:7500:6B00:799A:3186:4714:1000",
 "20248":{"ResponseCode":{"Code":5,"Desc":"DigSig Verification accepted; No error"},
          "DDDdataTagged":{"specificationversion":"ISO/IEC 20248:2018","timestamp":1511246331,
          "daid":"QC FVXX","cid":107,"dauri":"https://da.fleetvalid.info",
          "license_plate":"QCOP75",
          "plate_placing":"FRONT",
          "vehicle_colour":"WHITE",
          "vehicle_shape":"SEDAN",
          "tid":"4sBokiAAMAAePDZn"
          "signature":"BSeYOt9ajay_RrTKYIOKN6Uz-9txxKXFQMambkWAKi4="}}}
```


RCI enforces correct tag data programming

Write field with tuple definition	Default tuple values
"Write":[[<MB>,<start>,[<method>],<check>,<lock>]…]	[2,0,["VAL",""],false,"NO-CHANGE"]
"WriteEPC":[<binary>,<check>,<lock>]	["",false,"NO-CHANGE"]
"WriteUII":[<binary>,[<AFI>,<DSFID>],<check>,<lock>]	["",[":01",""],false,"NO-CHANGE"] where a DSFID = "" means there is no DSFID.
"WriteUM":[<binary>,<DSFID>,<check>,<lock>]	["","",false,"NO-CHANGE"] where a DSFID = "" means there is no DSFID.
"WriteAccessPWD": [<binary>,<check>,<lock>]	["",false,"NO-CHANGE"]
"WriteKillPWD": [<binary>,<check>,<lock>]	["",false,"NO-CHANGE"]

An RCI example

Write

The following RCI SpotProfile is used to instruct a reader to program the next tag in the read zone with the example IATA bag tag data. The write will be checked, and the tag locked:

```
{"Cmd":"AddProf","WriteUII":[":0C21:0501:2345:6789:1202:015E",[":C1"],true,"SECURED"]}
```

Read

The following RCI SpotProfile is used to instruct a reader to only read and report each detected IATA bag tag once.
The RCI defaults ensure minimalistic configuration:

```
{"Cmd":"AddProf","EncodingType":":C1"}
```

Report

The above example will be reported as follows:

```
{"Report":"TagEvent","AFI":":C1","UII":":0C21:0501:2345:6789:1202:015E"}
```

RAIN sensors

Sensor	Specification	Mode	Battery assisted	Report from
ALARMSENSOR	ISO/IEC 18000-63, Vendor defined sensor	Typically a tripwire sensor sensed during inventory	Not required	INVENTORY – XPC_W1
SNAPSHOTSENSOR	ISO/IEC 18000-63	A defined sensor type sensed during inventory	Not required	INVENTORY – XPC_W2
SIMPLESENSOR	ISO/IEC 18000-63	A defined sensor type which is self-monitored	Required	INVENTORY – XPC_W2
FULLSENSOR	ISO/IEC 18000-63, ISO/IEC/IEEE 21451	A defined sensor type which is self-monitored	Required	ACCESS command-response

A vendor defined tripwire alarm report example (TagUse interpretation is enabled).

```
{"Report":"TagEvent","AFI":":C1","UII":":0C21:0501:2345:6789:1202:015E",
 "TagIndicator":["ALARMSENSOR"]}
```

Simple sensors

Simple sensors monitor the environmental characteristic for which they are designed. A simple sensor tag is self-monitoring and takes samples at defined intervals, computes pass/fail based on its characteristics, and report its status.

RCI field name	Sensor
TempC14	0000_2 temperature sensor with span of 14°C
TempC28	0001_2 temperature sensor with span of 28°C
Humidity	0010_2 relative humidity sensor
Impact	0011_2 impact sensor
Tilt	0100_2 tilt sensor

RCI sensor alarm value	Sensor alarm
"LowBat"	Low battery
"Tamper"	Tamper
"TooHigh"	Delayed high out-of-range
"TooLow"	Delayed low out-of-range (not used by impact or tilt)

A tag with a temperature and impact monitoring sensor report example (SIMPLESENSOR interpretation is enabled).

```
{"Report":"TagEvent","AFI":":C1","UII":":0C21:0501:2345:6789:1202:015E",
 "SIMPLESENSOR":{"ResponseCode":{"Code":0,"Desc":"OK"},
                 "SimpleSensor":{"TempC14":[],"Impact":["BatLow","TooHigh"]}}}
```

Snapshot sensors

Snapshot sensors generate a sensor measurement essentially in real-time as a reader inventories the tag.

The sensor measurement may occur during power-up or on demand from a reader. The tag delivers the sensor measurement via XPC_W2 during INVENTORY and with a read ACCESS.

Sensor	Sensor name	Units	Sensor value
Vendor Defined (VenDef)	VenDef	VenDef	For the 2-bit data type: 00_2: null (measurement error) 01_2: 10-bit HexString 10_2: JSON non-negative number 11_2: JSON number
Temperature	TempC	°C	JSON number
Relative Humidity	RelHumidity	%	JSON number
Barometric Pressure	BarPress	hPa (mbar)	JSON number
Light	Light	lux	JSON number
Voltage	Voltage	V	JSON number
Magnetic Field	MagField	mT (10G)	JSON number
Angular Position	AngularPos	°	JSON number
Rotational Speed	RotSpeed	rpm	JSON number
Weight	Weight	kg	JSON number
Liquid Flow	LiquidFlow	ml/min	JSON number
Gas Flow	GasFlow	l_n/min	JSON number
Accelerometer	Accelerometer	G (9.81m/s^2)	A JSON number tuple [X,Y,Z]
Gyroscope	Gyroscope	°/s	A JSON number tuple [X,Y,Z]
Magnetometer	Magnetometer	µT	A JSON number tuple [X,Y,Z]
VenDef Supplemental Data	VenDefData	n/a	HexString

```
{"Report":"TagEvent","AFI":":C1","UII":":0C21:0501:2345:6789:1202:015E",
 "SNAPSHOTSENSOR":{"ResponseCode":{"Code":0,"Desc":"OK"},
                   "Weight":2.3,"Accelerometer":[213,4,789],"VenDefData":":ABCD"}}
```

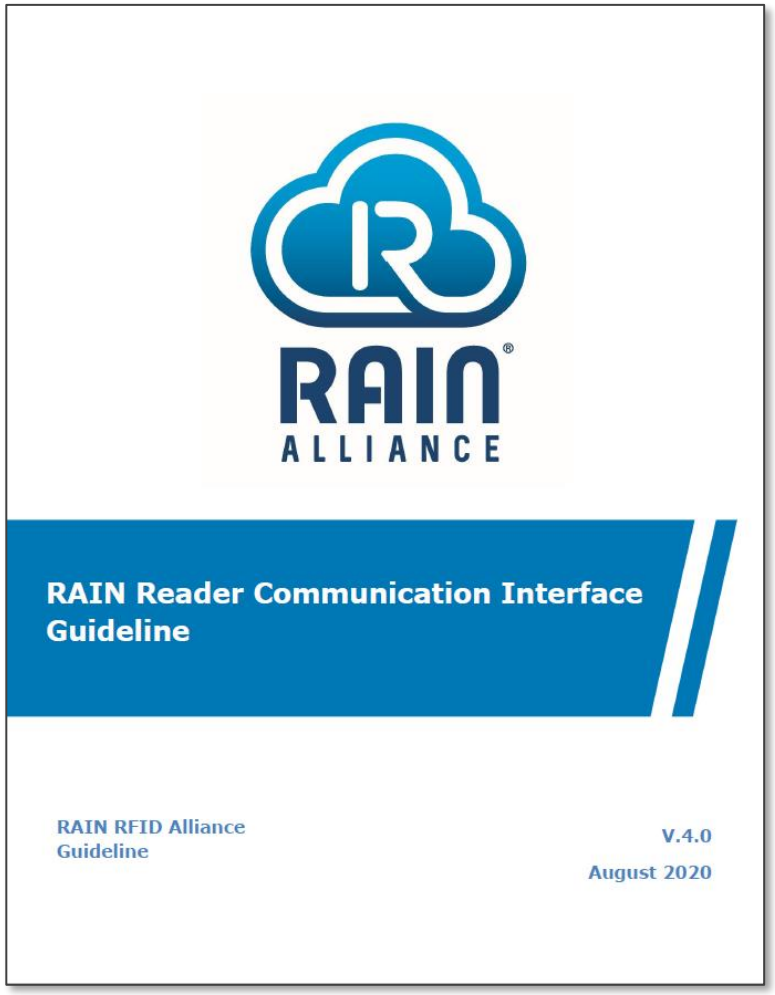
Crypto

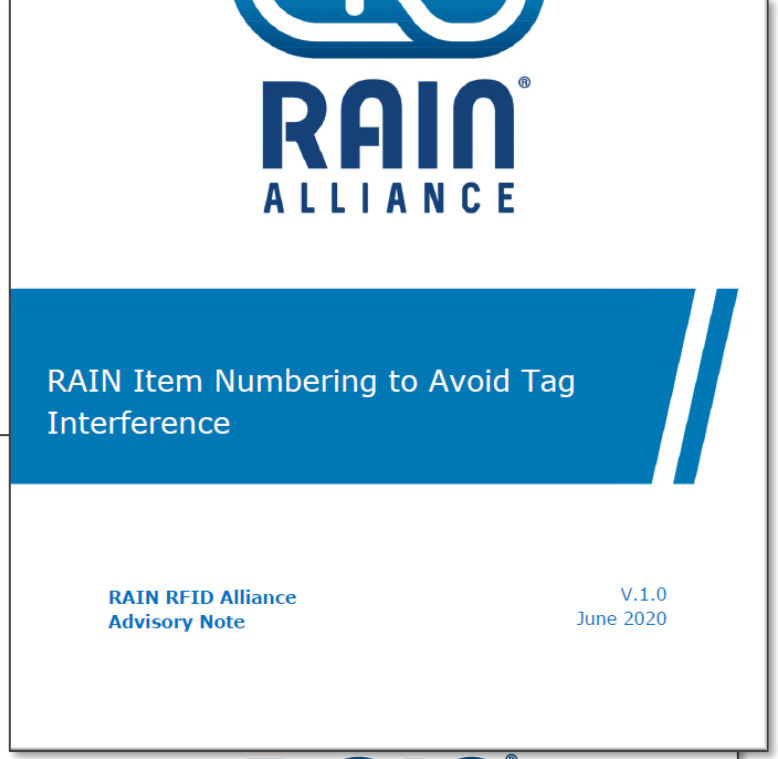
RCI Version 4 specifies the tag crypto read methods for TagAuth and private data for current products implementing ISO/IEC 29167 parts 10 and 13.

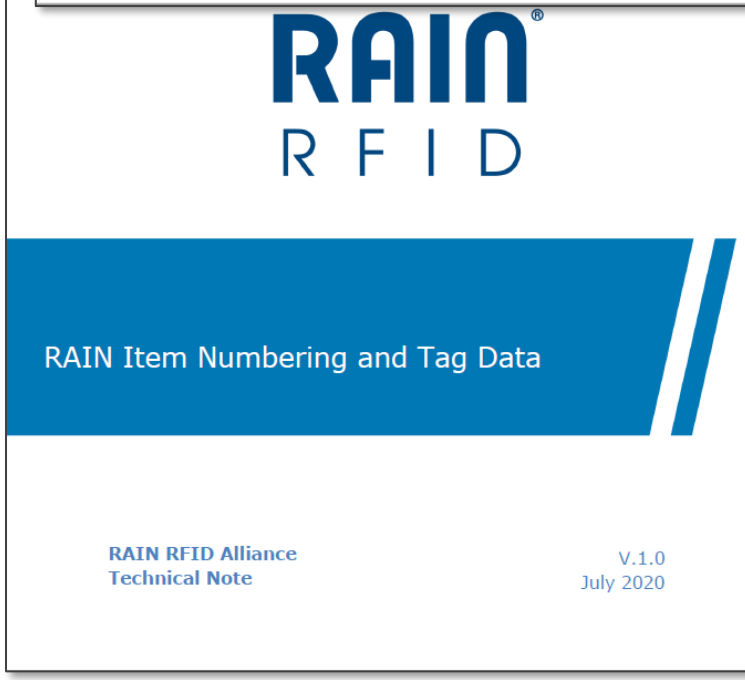
Encrypted tag data may be decrypted by the reader (directly) and by an application typically remote from the reader (by proxy).

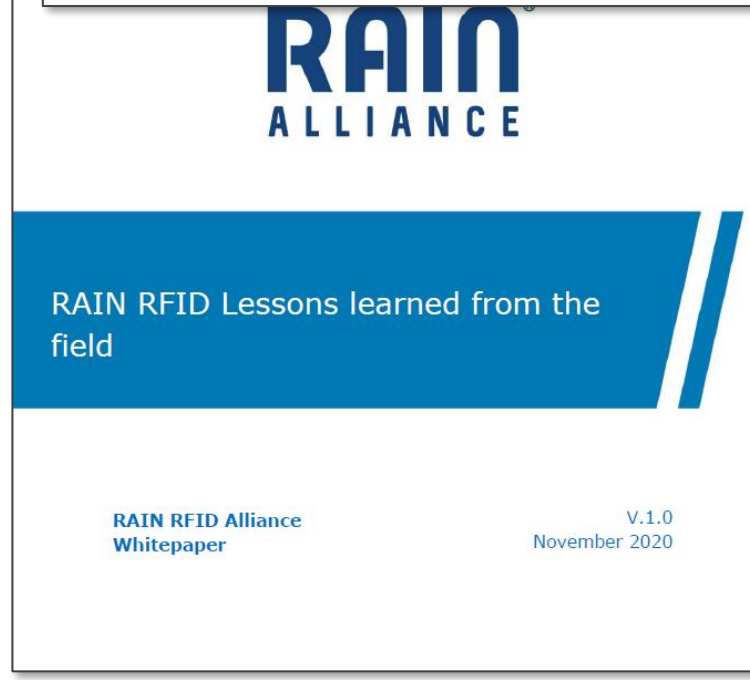
Fieldname	Value type	Default	Notes
Crypto	"AES-128-0", "AES-128-1" or "GRAIN-128A"	-	Defines the cryptography method to use. This is a compulsory field for TagAuth and PrivateData.
Key	Binary or URI	null	The Key value is a binary key or a key pointer. A key pointer is an URI which points to the location where the key can be obtained. The default value is null. When Key is set to null or omitted, then the reader does not decrypt and simply reports the challenge and the cypher text.
KeyID	Number	1	The KeyID value is a non-negative number.
KeyDiv	"NONE", "AES-128-CMAC" or "HKDF"	"NONE"	Specified by NIST Special Publication 800-38B, IETF RFC 4493 and IETF RFC 5869.
Report	"OPEN", "OPROXY" or "PROXY"	"OPEN"	Decrypted, decrypted with the information for a proxy check, or encrypted with the information for a proxy decryption.

RAIN publications









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