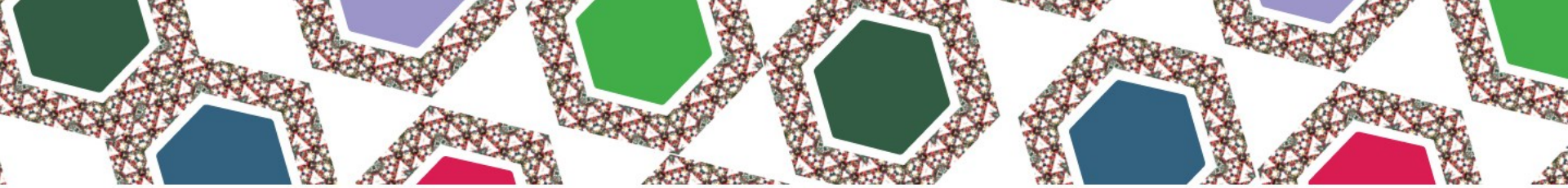


ITU Kaleidoscope 2013
Building Sustainable Communities

Using the RFID technology to create a low-cost communication channel for data exchange

Antonio Iera
A.R.T.S. Lab, University of Reggio Calabria, Italy
antonio.iera@unirc.it

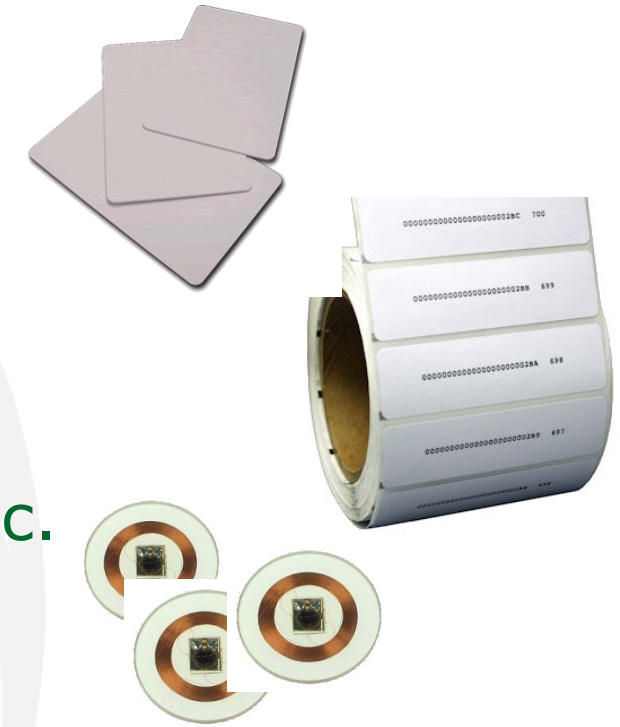
Kyoto, Japan
22-24 April 2013

Outline

- Motivations for the conducted research
- Scenarios and Applications
- Proposal
  - Objectives
  - The proposal step-by-step
- Performance Analysis
  - Simulation results
  - Conclusions

RFID Ecosystems: enabling factors

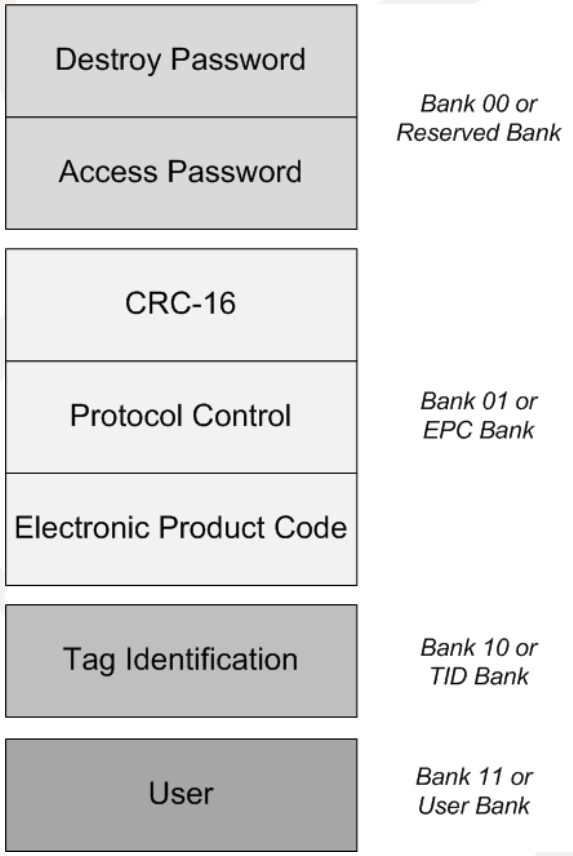
- Massive spread of the RFID technology: fast raising number of RFID-tagged objects
- Augmented tag storage capability
- Unconventional uses of the RFID technology: positioning, energy savings, environmental sensing, etc.
- RFID-based IoT platforms



- Miniaturization of mobile RFID reader

…one missing brick: a low cost RFID communication channel (1/4)

- RFID conventional use: tracking object

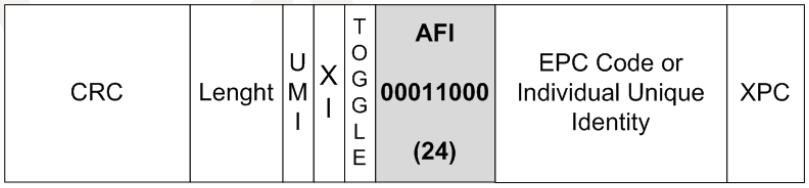


- The EPCglobal platform foresees to store an EPC code in every tag attached to an object
- User Memory bank (typically 512 bits) often unexploited

…one missing brick: a low cost RFID communication channel (2/4)

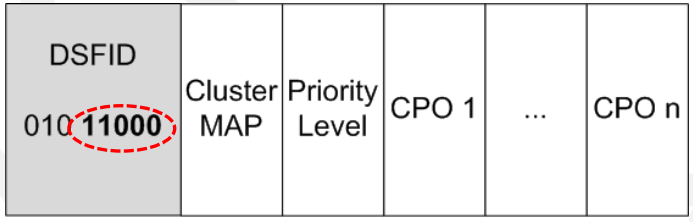
Novel User Memory Structure

- Interoperability with ISO/IEC 15962 standard
- New Application Family Identifier (AFI) according to ISO/IEC 15961



EPC Bank

- New Data Format (last 5 DSFID bits)



User Memory Bank

AI	Name	Data Title	Format Binary	#CPO
0	Cluster Map	CM	1*n bit	
1	Priority Level	PL	2*n bit	
2	ID Reader Source	IDRS	5 bit	
3	ID Reader Destination	IDRD	5 bit	
4	ID RAN	IDRAN	2 bit	
5	Count Success	CS	4 bit	
6	Count Insuccess	CI	4 bit	
7	Sequence Number	SN	5 bit	
8	Reader Address Lease	RAL	5 bit	
9	ID Master	IDM	5 bit	
10	ID RAN Lease	IDRANL	2 bit	
11	Reservation Bits	RB	2 bit	
12	Check Bits	CB	2 bit	
13	Payload	PLD	76 bit	1
14	ID Reader Source	IDRS	5 bit	
15	ID Reader Destination	IDRD	5 bit	
16	ID RAN	IDRAN	2 bit	
17	Count Success	CS	4 bit	
18	Count Insuccess	CI	4 bit	
19	Sequence Number	SN	5 bit	
20	Reader Address Lease	RAL	5 bit	
21	ID Master	IDM	5 bit	
22	ID RAN Lease	IDRANL	2 bit	
23	Reservation Bits	RB	2 bit	
24	Check Bits	CB	2 bit	
25	Payload	PLD	76 bit	
26	Bit unused		8 bit	2
…	…	…	…	

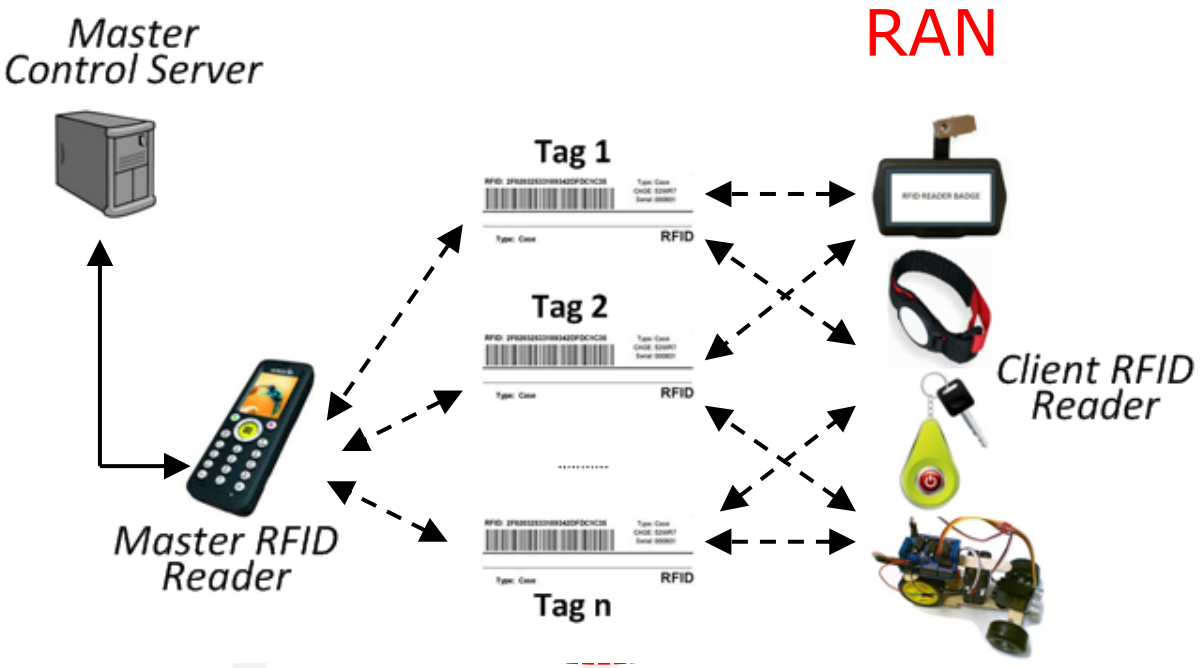
CPO

DATA PACKET | CONTROL PACKET

…one missing brick: a low cost RFID communication channel (3/4)

Accessing the new virtual channel

- A piconet of mobile readers called RAN (RFID Area Network) is established
- Readers' data exchange by using the residual memory of passive tags is enabled



- No competition with existing wireless short-range technologies (different target)
- Complementarity with direct RF communications

…the missing brick: a low cost RFID communication channel (4/4)

- Full compatibility with EPCglobal standards

- No extra hardware in the readers

- Novel paradigm of communication exploiting the RFID tag's persistent storage capability

New application domains

Scenarios and Applications

Indoor Positioning

Distributed Sensing

Distributed Search

Home Automation and Monitoring

Robot-to-Robot

Assisted Living and Telemedicine

Environments and involved devices

Applications	Environments	Involved devices
Precise positioning and location tracking	Indoor areas, automated homes, museums, expo areas, etc., wherein only RFID technology is available	Low-cost mobile readers (also embedded) exchanging data for cooperative RFID positioning
Distributed sensing	Indoor scenarios such as homes, offices, warehouses; generic outdoor scenarios; Body Area Networks for Health monitoring; stages of the supply chain; etc.	Low-cost miniaturized RFID readers distributed in the area that gather data from sensorized RFID tags, and exchange them to reach a complex RFID reader connected to the Internet.
Distributed search engines	Warehouses; museums; libraries; archives; harbor yards; etc.	A few fixed multi-technology RFID readers and many low cost, mobile, single-technology (RFID) readers
Device-to-device communication	Home, factory, and office automation environments, hospitals, logistics environments, etc.	Embedded devices with RFID capabilities, smart things, industrial machinery, exchanging low bit-rate data at a very low cost to implement collective tasks
Robot control and inter-communication	Indoor or outdoor environments (such as emergency areas, hazard areas, etc.)	Robots in a swarm, exchanging: positions, sensed data, and other useful control information

The proposed paradigm (1/3)

Addressing Phase

- Discovery and setting of tags available as a Communication Channel
- Creation of the RFID Area Network by Master Reader
- Joining a RAN by Client Reader
- Building of Discovery Table to know which tags to use for message exchange between readers

The proposed paradigm (2/3)

Communication Phase

- Unicasting messages with explicit acknowledgment
- Broadcasting messages
- Implementing a *Memory Resource Management* to guarantee efficient reuse of memory and introduce the possibility of having differentiated Priority Levels for dissimilar traffics

The proposed paradigm (3/3)

Control Phase

- Updating and maintaining the Discovery Tables
  - Control Phase verified by the MR
  - Control Phase verified by the CR
  - Control Phase with tag verification

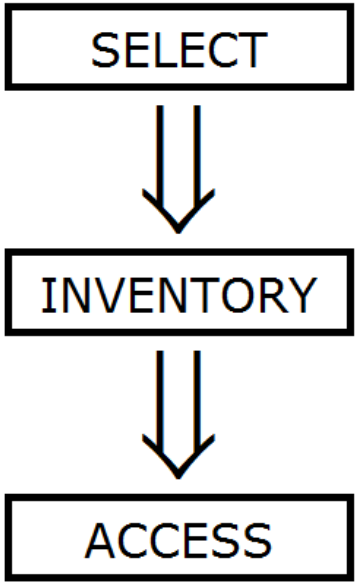
Performance evaluation of RFID low cost channel (1/3)

- Theoretical study in terms of *Bit rate* and *Data Rate*
- *Upper Bound* under ideal conditions and for the following Gen2 standard parameters

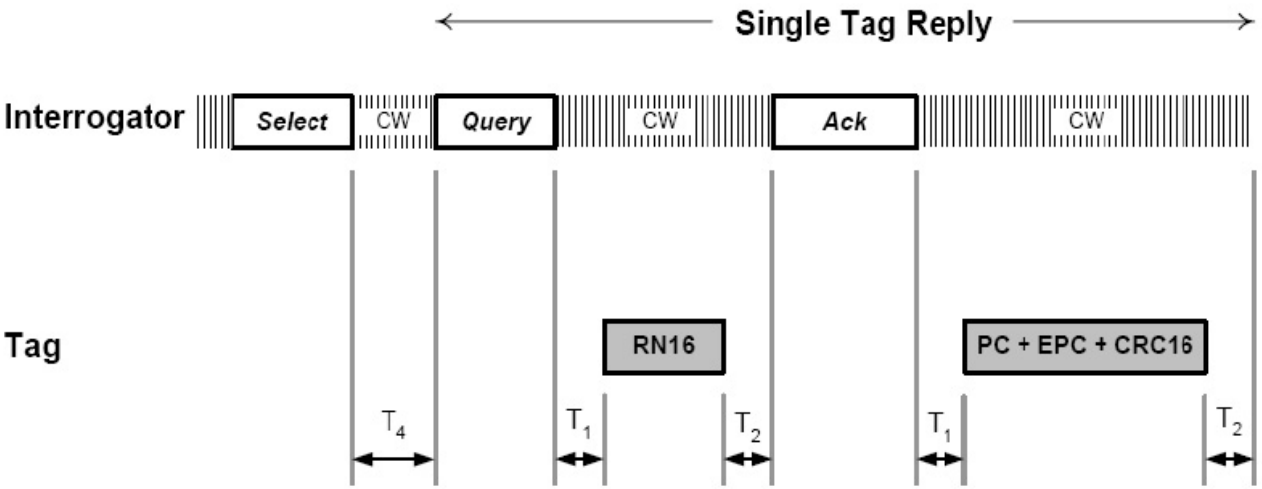
Parameters	
Tari	12.5 µs
Transmission Rate R->T	80 Kbps
Transmission Rate T->R	160 Kbps
Preamble	
Interrogator-to-Tag Preamble	112.5 µs
Interrogator-to-Tag Frame_Sync	62.5 µs
Tag-to-Interrogator Preamble	112.5 µs
Reader Command	
Select	912.5 µs
Query	525 µs
QueryRep	137.5 µs
ACK	400 µs
Req_RN16	812.5 µs
Read	1150 µs
Write	1300 µs
Tag Response	
RN16	225 µs
PC+EPC+CRC16	925 µs
Handle	325 µs
Timing Requirements	
T1	62.5 µs
T2	62.5 µs
T3	62.5 µs
T4	112.5 µs

Performance evaluation of RFID low cost channel (2/3)

- EPCglobal Gen2 Class1 UHF RFID protocol



- *A successful inventory* implies that a specific data exchange happens:



Performance evaluation of RFID low cost channel (3/3)

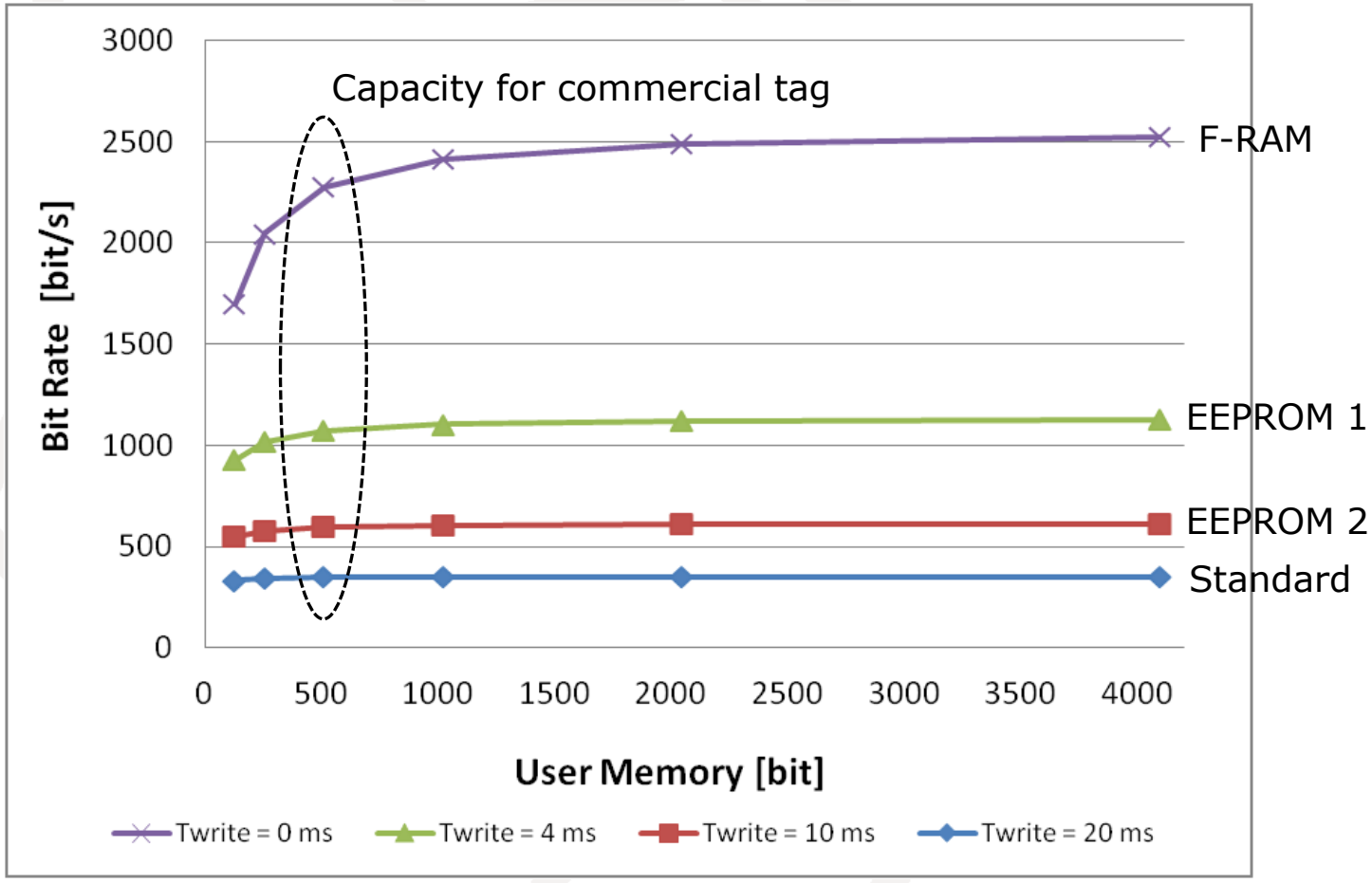
Reference scenario

Reliable messages exchange between a MR and a CR via a single tag for different User Memory Size

- Tag quality:
  - F-RAM
  - EEPROM
  - Standard
- Two write methods:
  - Write Command
  - BlockWrite Command

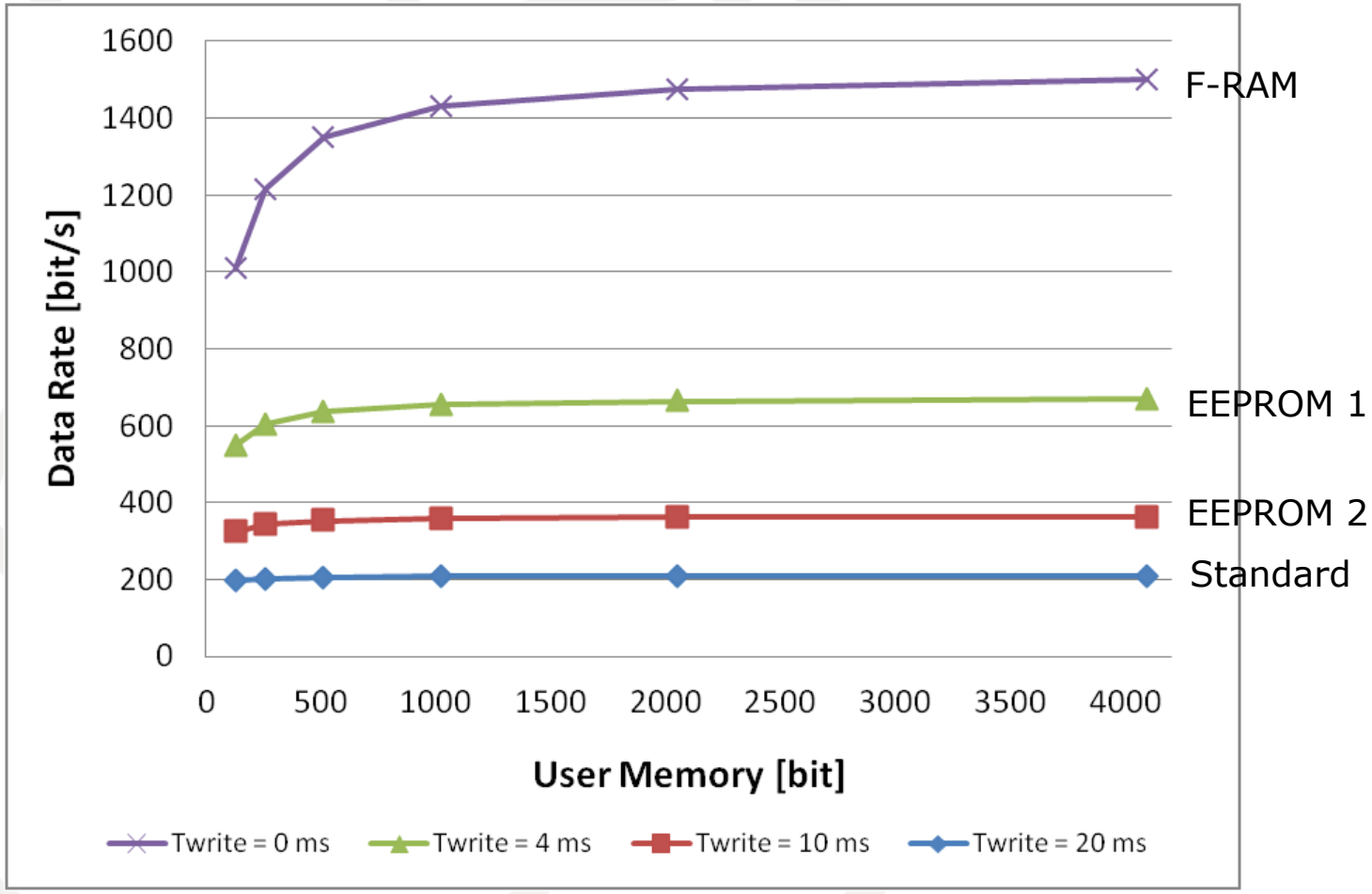
Simulation Results (1/4)

- Bit Rate - "Write Command" method



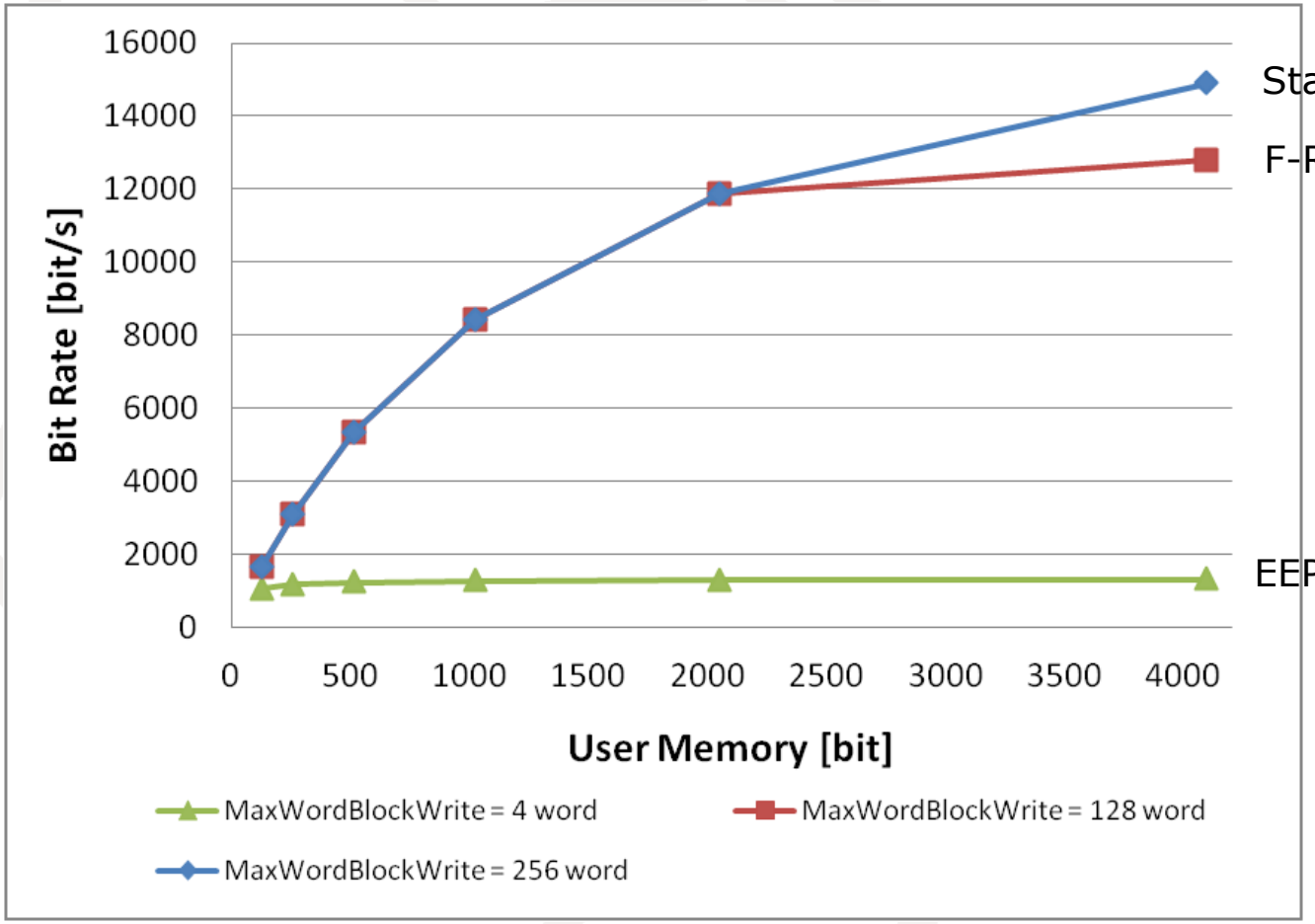
Simulation Results (2/4)

- Data Rate - "Write Command" method



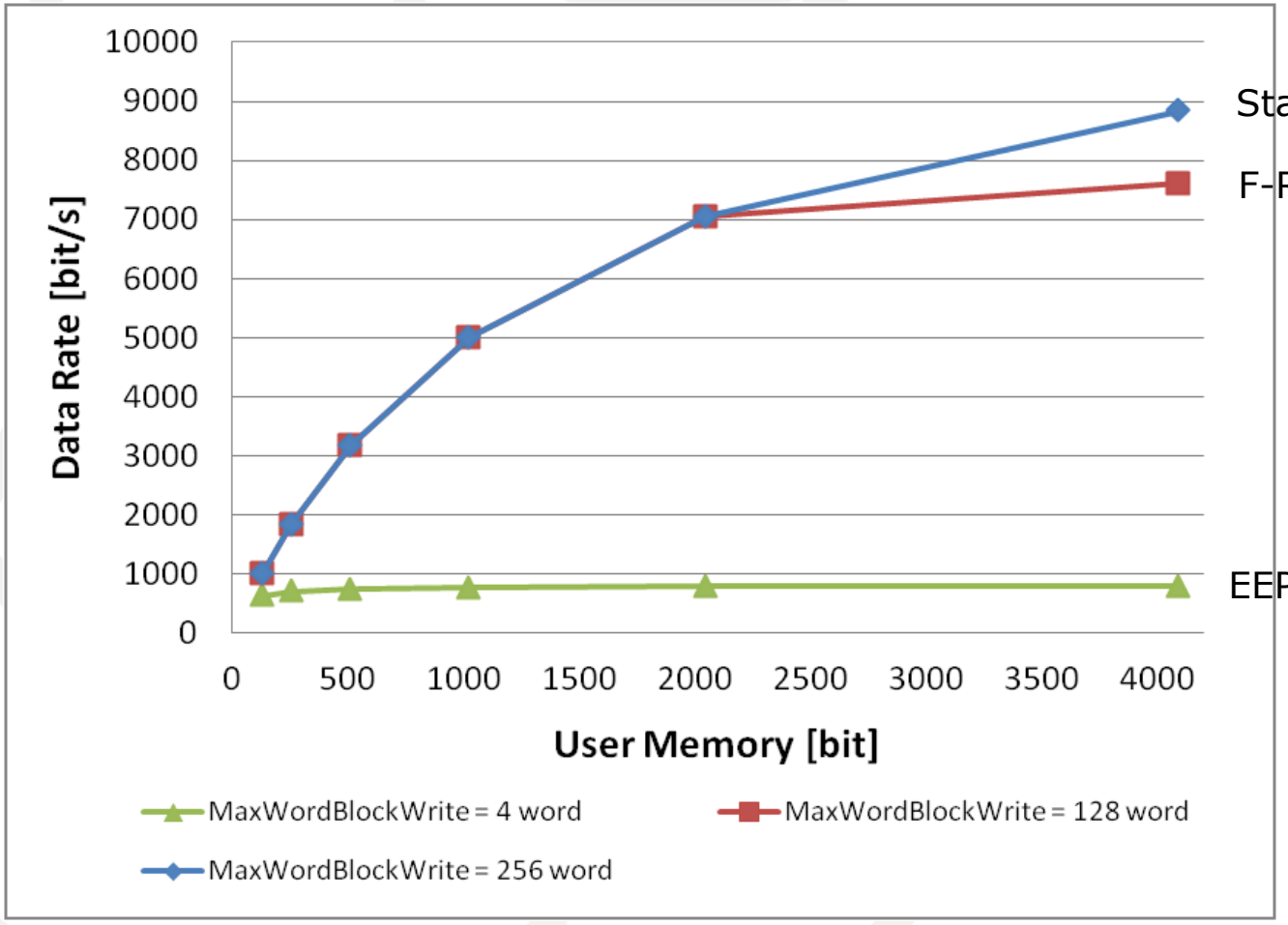
Simulation Results (3/4)

- Bit Rate - "BlockWrite Command" method



Simulation Results (4/4)

- Data Rate - “BlockWrite Command” method



Conclusions

- A new low cost communication channel has been investigated
- A new AFI is proposed (input to standardization)
- A new Data Format is proposed (input to standardization)
- A novel organization of the User Memory Bank interoperable with ISO/IEC 15962 is considered (input to standardization)

- Several work is required to better investigate some issues: interferences, collisions, dynamic RAN, partial failure of write operations

- We are currently working on the proposal of ad-hoc protocols facing collision and interference problems in RANs with multiple readers

ITU Kaleidoscope 2013

Building Sustainable Communities

THANKS FOR YOUR ATTENTION!

Kyoto, Japan
22-24 April 2013