Green Smart Dust Networks: Few Challenges and Possible Solutions

Jahangir H. Sarker

School of Information Technology and Engineering (SITE),
University of Ottawa, Ottawa, Ontario, Canada K1N 6N5
E-mail: jsarker@site.uottawa.ca
Outline of the Presentation

• How RFID works?
• How mobile RFID works?
• Applications of wireless sensor networks.
• Use of RFID in the zoo for real-time animal monitoring.
• Group dancing mobile flower robots.
• Dust networks.
• Few challenges and few solutions.
• Conclusions
How Static RFID Work 1/(2)?
How Static RFID Work 2/(2)?
How Mobile RFID Works 1/(4)?
How Mobile RFID Works 2/(4)?
How Mobile RFID Works 3/(4)?
Success = $G e^{-G}$

Active $\lambda$ Channel

1st Failure $\frac{n_1 q}{\lambda (1 - e^{-G})}$

2nd Failure $\frac{n_2 q}{n_1 q (1 - e^{-G})}$

$r$th Failure $\frac{n_r q}{n_{r-1} q (1 - e^{-G})}$

$(r+1)$th Failure $n_r q (1 - e^{-G})$
Applications of Wireless Sensor Networks

Organisation for Economic Co-operation and Development (OECD)
Tracking and Identification of Animals for a Digital Zoo

Source: Johannes Karlsson, Keni Ren and Haibo Li, 2010 IEEE/ACM International Conference on Green Computing and Communications
Picture of two deployed camera nodes in the zoo.
Overview of the devices used in our RFID experimental setup.
Tracking and Identification of Animals for a Digital Zoo 4/(4)

(a) Single individual tracking.  
(b) Multiple object tracking.

Tracking of animals in the zoo.
Group Dancing Mobile Flower Robots 1/(6)

Mobile Flower robot

January 12, 2012

J. H. Sarker / SITE.uOttawa.ca/~jsarker
Movements of Mobile Platform
Communication system by ZigBee module
Mechanism of Blooming Motion
Mechanism of Swaying Motion
Group Dancing Mobile Flower Robots 6/(6)

What is the Future?

• In the zoo, animal monitoring, reader fixed, tag moving.
• In group dancing mobile flower robots, tags are fixed as smart floor and readers are dancing.
• In future, both will be mobile:
  • Dust networks.
Main Challenges & Solutions

• Sensors, indicators and RFID systems should be very cheap.

• The technologies should be chipless and green.
Solutions

RFID can be used widely in almost all items
✓ Price per tag is an important issue

- Printed ID tags will cost less than one cent
- Chris Snow February 22, 2011 IDTechEx (Cambridge, MA, USA), an M2M-sector analyst firm, has released their
Printed Electronics: Market Forecast

Printed and thin film electronics
Displays, RFID, Smart Packaging, New market creation

Source: IDTechEx

$55 B by 2020
Printed Electronics: Antenna 1/(2)

Source: Li Yang, Amin Rida, Jiexin Li, and Manos M. Tentzeris, Antenna Advancement Techniques and Integration of RFID Electronics on Organic Substrates for UHF RFID Applications in Automotive Sensing and Vehicle Security, 2007
Printed Electronics: Antenna 2/(2)

Organic Light Emitting Diodes & Solar Cell

**OLED**  
Organic Light-Emitting Diodes

- Metal Cathode
- Emitter (~100 nm)
- Hole transport layer (~100 nm)
- ITO/Anode (~100 nm)
- Substrate

**OSC**  
Organic Solar Cell

- Metal Cathode
- Active polymer blend (~150 - 300 nm)
- Hole transport layer (~40 nm)
- ITO/Anode (~100 nm)
- Substrate

Source: VTT 2009
Organic Solar Cell

Gravure printed OSCs on flexible ITO-PET substrate:
- Gravure printed PEDOT (air processing)
- Gravure printed P3HT:PCBM (air processing)
- Evaporated cathode
- All R2R process during 2011

$V_{oc} = 0.61 \text{ V}$
$I_{sc} = 5.41 \text{ mA/cm}^2$
$FF = 0.52$
$\eta = 2.82 \% \text{ (AM1.5 reference)}$

© VTT 2011
Progress Towards the First Wireless Sensor Networks

Progress Towards the First Wireless Sensor Networks

Probability of success with 1-packet reception capability per node and **without jamming signals**

**Transmitting probability $b$**

- $J=0$, $r=1$
- $t=1$, $2$, $5$, $10$, $50$

**Receiving probability $c$**

- $J=0$, $r=1$
- $t=1$, $2$, $5$, $10$, $50$
Probability of success with 1-packet reception capability per node and with jamming signals

\[ P(S_u) = 0.3, \quad r = 1 \]

Transmitting probability \( b \)

Receiving probability \( c \)
Mitigating the effect of maximum throughput reduction: Single transmitter or single receiver

\[
S_{\text{opt}}(r, J) = \begin{cases} 
0.5 & \text{if } r = 1, J = 0 \\
0.4 & \text{if } r = 1, J = 0.1 \\
0.3 & \text{if } r = 1, J = 0.2 \\
0.2 & \text{if } r = 1, J = 0.3 \\
0.1 & \text{if } r = 1, J = 0.4 \\
0 & \text{otherwise}
\end{cases}
\]

\[
S_{\text{opt}}(t, J) = \begin{cases} 
0.5 & \text{if } t = 1, J = 0 \\
0.4 & \text{if } t = 1, J = 0.1 \\
0.3 & \text{if } t = 1, J = 0.2 \\
0.2 & \text{if } t = 1, J = 0.3 \\
0.1 & \text{if } t = 1, J = 0.4 \\
0 & \text{otherwise}
\end{cases}
\]
Mitigating the effect of maximum throughput reduction: Multiple transmitters & multiple receivers

Source: J. H. Sarker and H. T. Mouftah, Mitigating the Effect of Jamming Signals in Wireless Ad Hoc and Sensor Networks, Accepted in *IET Communications*, 2011
Conclusions

- The working procedure of RFID systems have been discussed.
- Applications of wireless sensor networks is discussed.
- Use of RFID for animal tracking is discussed.
- Mobile robot dancing.
- Future is the green smart dust networks.
- Current and future of printed electronics has been discussed.
- The probability of success has two components:
  - the probability that a packet will be an authorized packet and
  - the probability that no other interfering packet in a receiver of a receiving node.
- Either multi-packet X-mission or only multi-packet reception can NOT work.
- Both multi-packet transmission and multi-packet reception capabilities are needed.
Thank you

Thanks a lot for

your kind attention
Questions?