The Cargo Container RF Tag

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Outline

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Why Radio Tags

There are many applications where we want to associate data with an object, and have that data readily available to a remote device.

Examples are: airline bag tags, tags for tracking cargo containers, tags for identifying animals
A Useful Classification

- **Tag data capacity**
  - 1 kb
  - 10 gb
  - 100 gb
  - 1 gb

- **Tag readout range**
  - 0.1 m
  - 1 m
  - 10 m
  - 100 m
  - 1 km

- **Tags**
  - Factory automation tags
  - Baggage tags
  - Bar code replacement
  - Truck & airline cargo container tags
  - Automobile toll tags
  - Warehouse inventory tags
  - Ship container tags
A more useful classification
The tag must be cheap. One way to make it cheap is to throw out a transmitter on the tag.

Even if there is no transmitter in the tag, we can still have two way communication with it.
Modulated Backscatter

The amplitude & phase of the reflected signal from the tag depend on the terminating impedance.
Modulated Backscatter
The Cargo Tag

• The Cargo Tag was built to satisfy the requirements of the International Air Transport Association (IATA). These included:
  – 5m read range
  – 10m/s tag speed
  – 6 tags simultaneously in the reading volume
  – 3 year battery life
  – Access to the contained data even if the battery has failed
The Cargo Tag
Other Applications

If we can make a tag with the functionality of the cargo tag for about $5 and locate it to within ~ 1 m (in three dimensions), we can potentially open up a market for $10^6$ to $10^8$ tags per year for inventory control applications.

If we can make a tag that holds ~ 32 bits for 10¢, we can potentially open up a market for $10^7$ to $10^9$ tags per year for airline baggage and express parcel tracking.

If we can make a tag for ~ 1 ¢, we can consider replacing printed bar codes.
Observations and Lessons for BWRC

• The Cargo Tag (and a related product in production) use 2 chips, one CMOS (digital) and one bipolar (analog). Three times the question of integration has been visited, and each time, the two chip, two technology solution has been cheapest.
  – Can you do better?
  – Are we missing something?
Observations and Lessons

• In the Cargo Tag project, we had a specific functional goal. However, there were many surprises, especially in the area of the radio channel (for example, we totally misunderstood modulated scattering interference - it was far worse than expected - and we failed to recognize the wide variability of Tx/Rx antenna isolation caused by the environment, leading to dynamic range problems.

• We would have liked to use a high level simulation tool to help us design our system.
  – How can we - at least - parameterize our uncertainty of the radio channel so we have a chance of catching problems in the simulation stage?
Observations and Lessons

• We looked at ways to power the tag from the incident RF field. With the 1W that can be transmitted in the ISM band, it is hard to get a range of more than about 50 cm.

  – Is there a technological trick or system approach that can do much better?