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# Radio Tags, Technology Snags and Market Lags: Finding a Future for Radio Frequency Identification

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# Outline

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- Why Radio Frequency Identification?
- RFID Markets
- RFID Technologies
- Companies Playing in RFID

# Why RFID?

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- Radio Frequency Identification (RFID) is generally intended to automate logistical operations by providing machine readable and writable label for objects.
- It may be considered an enhancement of existing methods (e.g., printed bar codes) for automatic object identification.

# Why RFID?

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- **Perceived Advantages of RFID:**

- » Non-line-of-sight (possibly built into or placed inside containers)
- » Long range
- » Many tags read out at once
- » Robust (not as fragile as a printed bar code)
- » Gives a path from simple identification of objects to locating objects
- » Almost as cheap as a printed bar code! (Almost....)

# RFID Markets

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- The RFID market splits into three broad areas:
  - » Large container or vehicle tracking using long range, high data capacity tags
  - » Factory or process automation using moderate capacity tags (i.e., toll tags)
  - » Airline luggage and parcel tracking using simple disposable tags.

# RFID Markets

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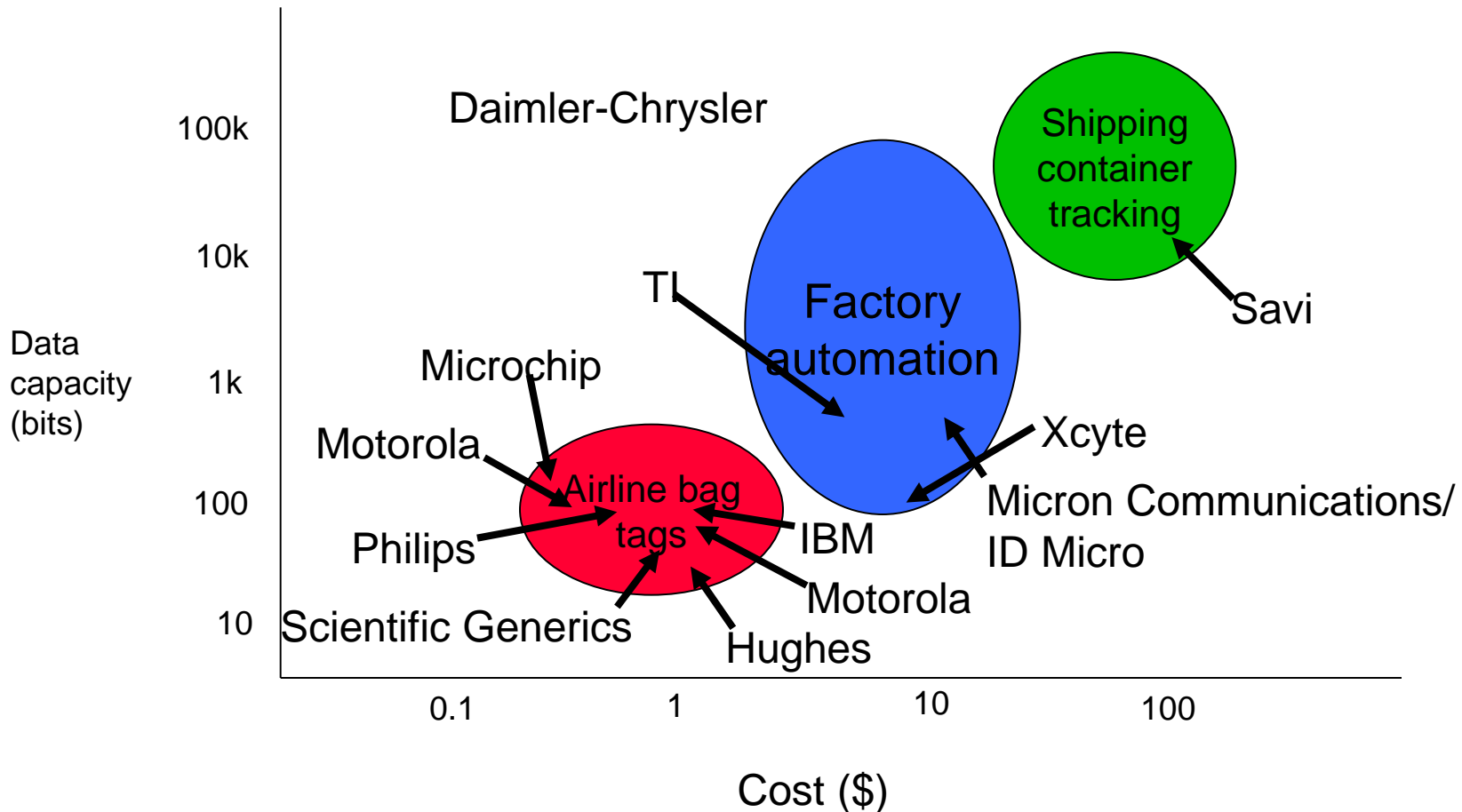
- A Frost & Sullivan report several years ago predicted that the RFID market would exceed \$1B by the year 2000. In reality, it is not even half of that.
  - » The fundamental problem is that RFID has been sold on the basis of the new capabilities it will supposedly offer, rather than on cost savings for existing operations.

# RFID Markets

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- Nevertheless, the potential markets are big:
  - » airline luggage tags:  $1 - 2 \times 10^9$  / year
  - » express parcel tags:  $2 - 5 \times 10^9$  / year
  - » RF postage stamp: around  $10^{10}$  / year
  - » RF bar code: around  $10^{11}$  / year
- The key is making the thing dirt cheap!

# RFID Markets



# RFID Technologies

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- A useful classification of RFID tags:
  - » Passive (no “electronics”)
  - » Semi-active (powered from incident RF, communicating via modulated backscatter)
  - » Active (containing a battery or other power source for long range communication)

# RFID Technologies

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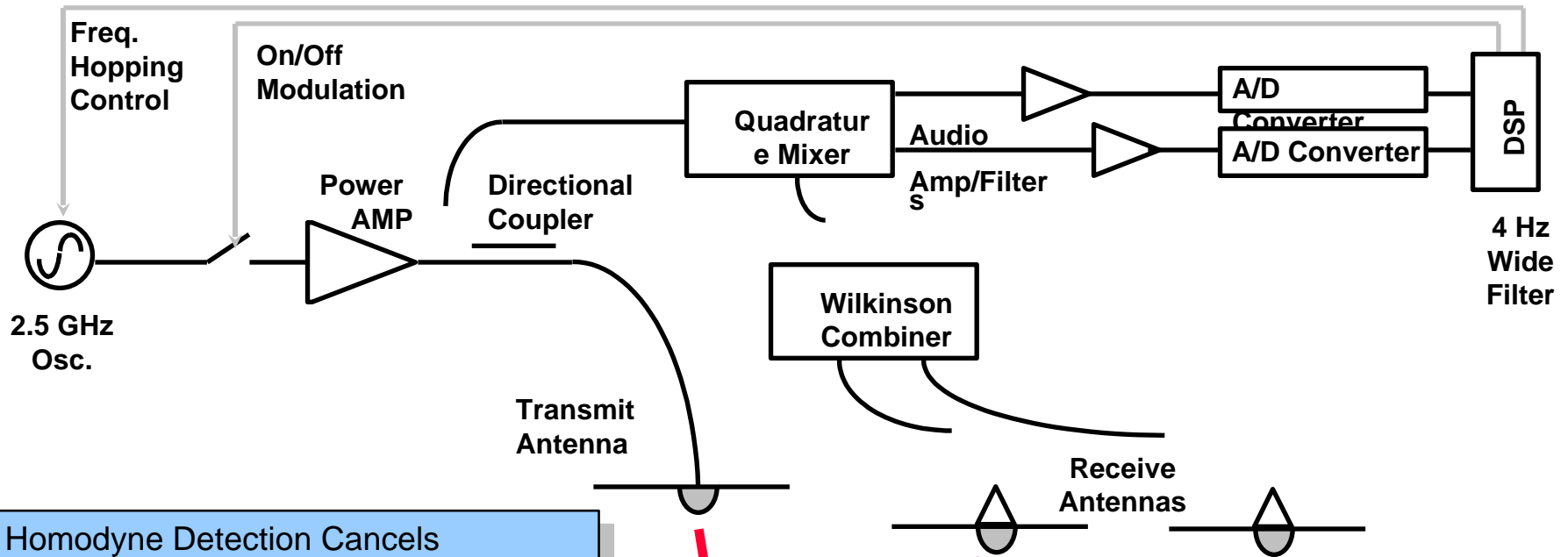
- Passive Tags:
  - » These tags encode information on a backscattered RF signal, but don't use electronics as we usually consider it.
  - » Examples are Xcyte's LiNb SAW tag and Scientific Generics magnetic/acoustic tag.
  - » Closely related are anti-theft tags (Sensormatic, Checkpoint)

# RFID Technologies

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- Semi-Active Tags:
  - » Most RFID tags manufactured today are in this category.
  - » Conventional Si processing is used to build the tag IC
  - » Semi-active tags use a wide range of RF frequencies, e.g., 125 kHz, 13 MHz, 910 MHz and 2.45 GHz.

# Communications Base Station Radio Architecture

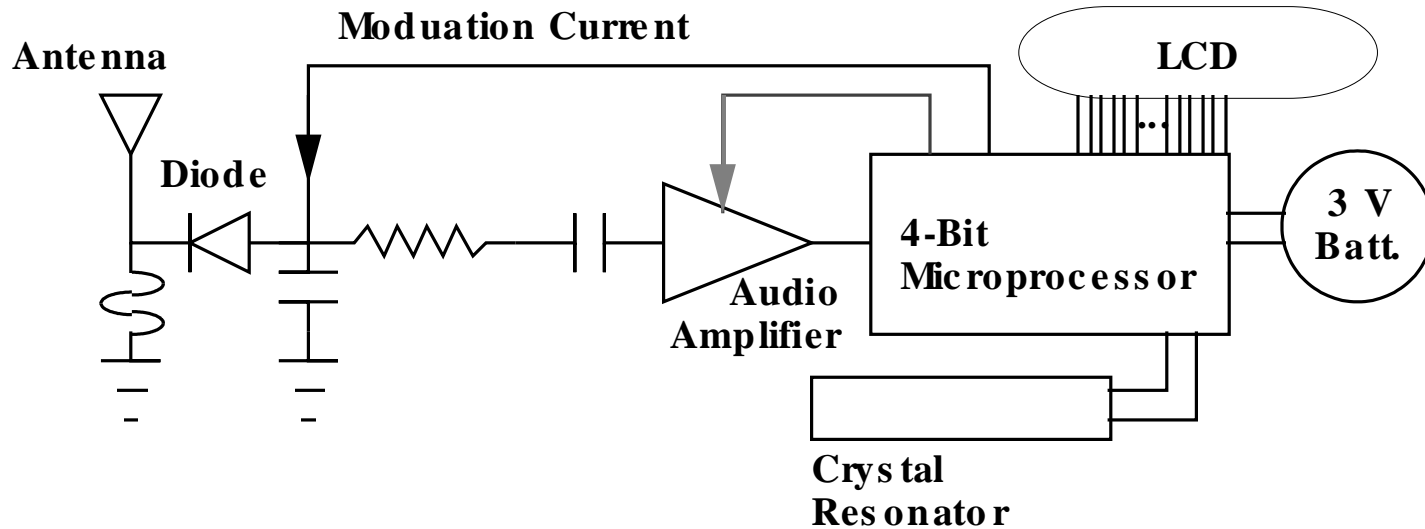


- Homodyne Detection Cancels Much Phase Noise
- 1 Watt Frequency Hopping Transmitter
- ON/OFF Keyed Modulation in Downlink
- Two-Rail Quadrature Receiver
- Several Narrow Band Receivers in DSP
- Multiple Receive Antennas for Diversity



Sideband Modulation

# Backscatter Tag Operation



- Same Diode Used in Receive and Acknowledgment Modes
- 1.5 mA Modulation Changes Reflection Coefficient of Antenna
- 3.2 microAmp (Average) LNA with 110 dB of gain
- 5 to 7 year battery life
- Communications Costs under \$1, Complete Tag Costs Under \$10

# RFID Technologies

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- Semi-active tags are usually divided into two subcategories: write-once and rewritable.
  - » Write-once tags are programmed when issued and typically use fuse-blowing. A special pad on the chip is used to supply the programming voltage.
  - » Rewritable tags require flash or FRAM memory on the chip.

# RFID Technologies

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- Active tags
  - » Active tags use a battery to power the receiver or transceiver.
  - » They can achieve long ranges (30 meters or somewhat more using modulated backscatter communication, hundreds of meters using an active transmitter)
  - » Battery life may not be a critical problem, depending on the communication duty cycle---the NCR electronic price label lasts 5 years on less than a half an amp hour battery.

# The Competitive Landscape

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Who has tried what, and have they succeeded?

# Competitive Landscape

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## Passive Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
Xcyte	parking lot pass	Does not seem to have expanded out of the parking lot pass niche. Needs expensive LiNb to achieve range of more than 1 m.
Scientificairline luggage/ animal tagging	No success in introducing magneto-acoustic tags to airline system integrators.	Generics

# Competitive Landscape

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## Semi-Active Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
Daimler- Chrysler	airline bags	Rewritable tag. Technology licensed from Intag (Australia). Mostly an integrator, not really a tag technology vendor.
Hughes	airline bags	Showed a low frequency (125 kHz) tag to airlines several years ago. No longer interested?

# Competitive Landscape

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## Semi-Active Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
IBM	supermarket bar-code replacement	2.45 GHz tag; didn't like being close to metal. Technology sold off.
Microchip	airline bags	Aggressively priced (\$0.30) low frequency tag. Early splash, now not much in the trade press.
Motorola (I)	factory automation	Some presence in the factory automation field with a low frequency tag. Tried to sell airlines a repackaged version of the factory tag.

# Competitive Landscape

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## Semi-Active Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
Motorola (II)	box tracking	Unique powering method of (perhaps?) the older factory automation tag. Uses capacitive coupling. Aimed at being embedded in cardboard boxes.
Philips	airline bags	Announced a 900 MHz tag aimed at airline bag tracking. Not a peep afterward.

# Competitive Landscape

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## Semi-Active Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
Micron	airline bags	2.45 GHz, long range was supposed to be a selling point. First company to try to build a 2.5 GHz radio in CMOS for a real high volume product. Did not succeed. Technology sold to IDMicro, a systems integrator. Interesting battery technology.

# Competitive Landscape

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## Semi-Active Tags:

<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
TI (TIRIS)	animal ID, factory automation, airline bags	Low frequency, rewritable tag. Well established in small niches, e.g., valuable animal labeling and tracking marathon runners. No success in the airline market. Apparently not a core technology direction for TI.

# Competitive Landscape

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## Active Tags:

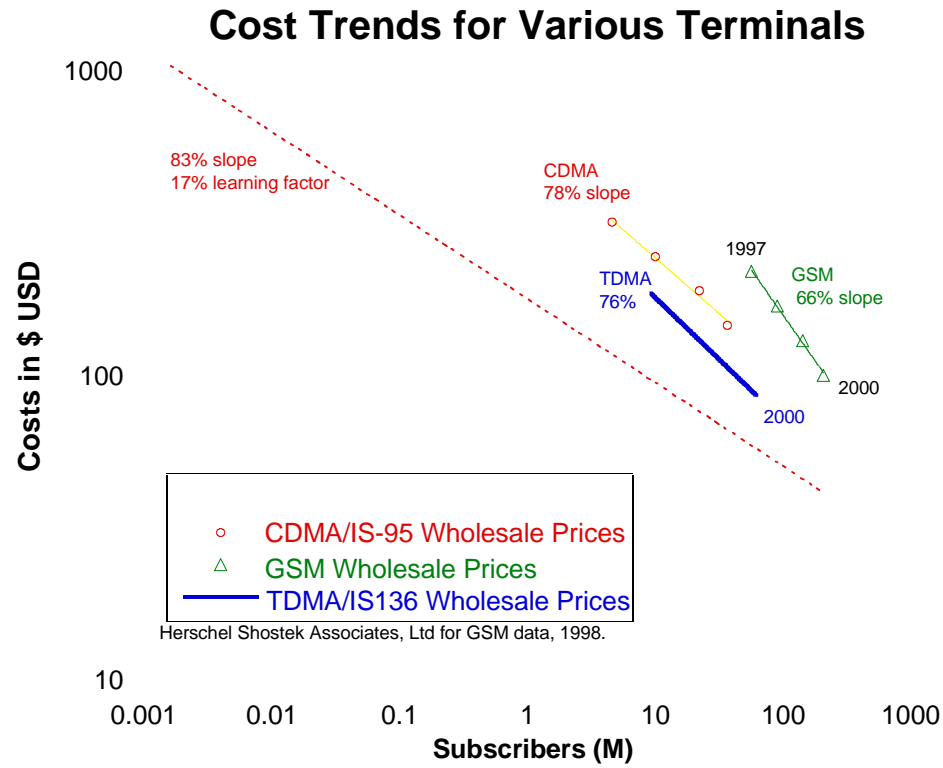
<u>Vendor</u>	<u>Application</u>	<u>Notes</u>
TI (Savi)	military shipping container tracking	Owens this niche but there are problems in finding a worldwide frequency allocation. (Original product operates at 300 MHz.) A parallel commercial market has not developed.
NCR	electronic price label	A niche market, but one of the few commercial successes of an RFID-like application.

# Conclusion

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- Cost is everything in RFID.
  - » The problem is you have to make a lot of something to learn how to make it cheaply.

# Learning Curves



# Conclusion

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If we can build a radio tag that encodes 40 to 100 bits, can be read at a range of 1 meter and sells for less than a dime, we'll be driving fancy cars & smoking expensive cigars.