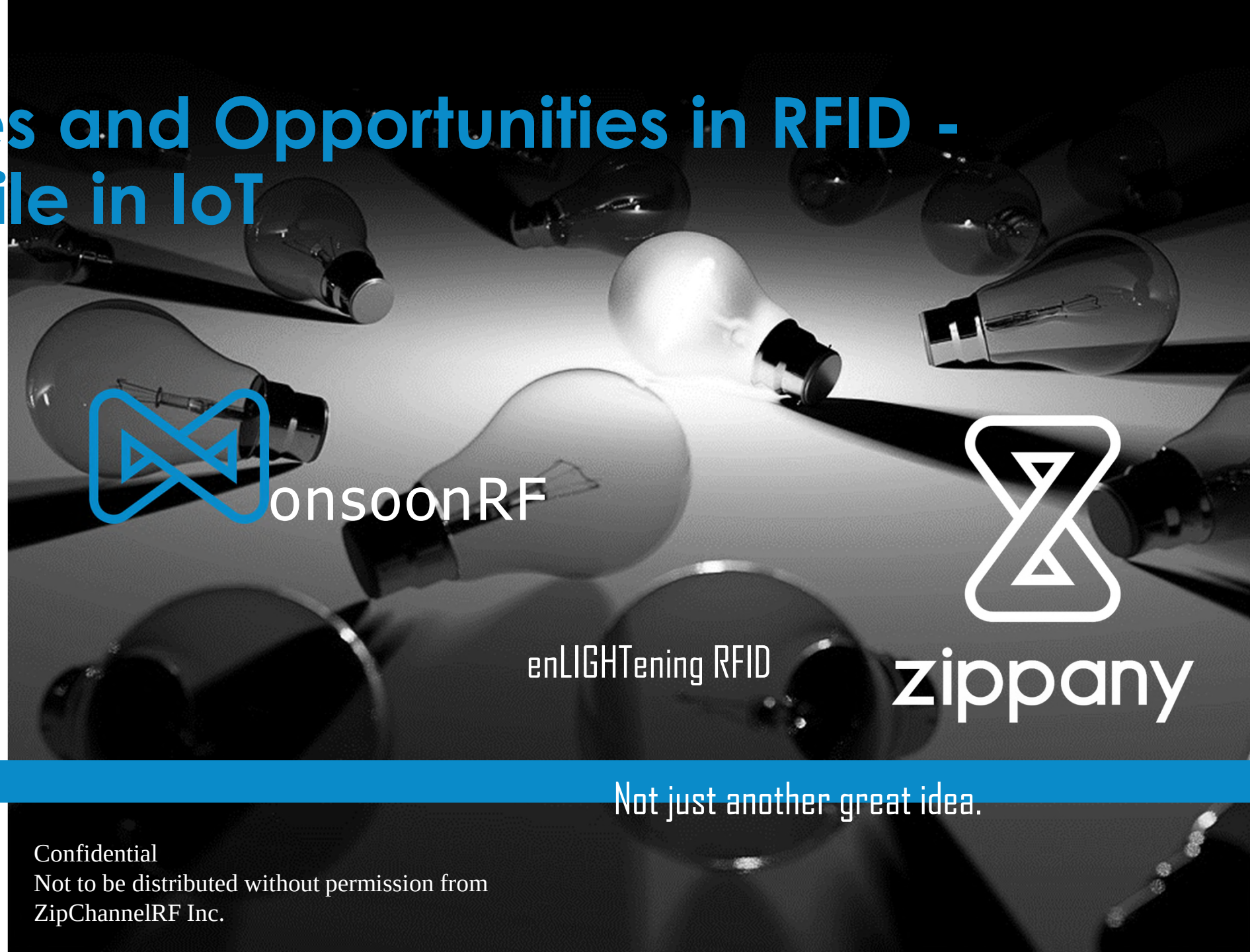
Challenges and Opportunities in RFID - the Last Mile in IoT

AIM and RAIN RFID

Engage AGAIN

5-6 May 2021

John T Armstrong



Journey to IoT

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KUKA SmartProduction

KUKA SmartProduction makes your production line ready for the future. By intelligently and securely connecting all manufacturing machines to the cloud, we increase your production efficiency and process quality in a sustainable manner.

https://www.kuka.com/en-us/future-production/industrie-4-0/industrie-4-0-smartproduction?sc_camp=B0AD2317B83C486B8944E1432344D0F2

All things to All people ←→ All people to All things

Automatically detect all IoT devices for a secure network.

All it takes is one exploitable IoT device to expose your network. ExtraHop Reveal(x) provides complete visibility of your entire network with real-time threat detection you can respond intelligently.

rahop.com/demo

"Mystery is Margin"
(Dave Berkus 1980)

PROMISE

TESTIMONIALS

OPPORTUNITY

The Intel Impinj powered solution delivers on the dream of hands-free, full-time inventory visibility. We get accuracy that is as good or better than with hand held readers, in real-time and with less work. We have been amazed at the effortless accuracy of the system to not only deliver counts but also item locations. This enables a wealth of possibilities in our roadmap towards a robust omnichannel shopping experience for our customers."

— Stacy Schulman, CIO American Apparel

THREAT

"an IT-connected device that is outside of the IT umbrella management, so not a server or laptop." That could include radio frequency identification (RFID) tags attached to pallets on long-distance ships or a restaurant grill that has a sensor tracking temperature and maintenance adherence.

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WHY USE RFID FOR THE LAST MILE IN IOT?

6 SIGMA FIRST STEP

You can manage,
what you can measure;
You can measure,
what you can define;
You can define,
what you understand.

In the words of quality guru William Edwards **Deming** (1900-1993):
"An operational definition is one that people can do business with.... It must be communicable, with the same meaning to vendor as to purchaser, same meaning yesterday and today..."

FIXED INFRASTRUCTURE RAIN RFID provides **low cost**, **reliable** Communication of the Facts on What, Where, When, and How Many

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Starting Point 2021 - Tools

TOOLS

- UHF RAIN RFID
- Ultra-Wideband (UWB), Bluetooth LE, BDM LTE
- CATM/NB-IoT
- Blockchain Enforced Ledgers
- ENCRYPTION

YOUR OPPORTUNITIES

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WITHOUT UBIQUITOUS GLOBAL IoT

1. Global waste of
   - time and resources due to unintended, undesirable, and unmonitorable delays between demand and fulfilment.
   - Items delivered (food, flowers, products) too late to be useful.
   - Large stockpiles everywhere

2. Need Factory 'Outlets' to sell overages, sometimes at or even below the manufacturing, distribution and storage costs already incurred.

3. Secondary (Gray) Markets that make up for hiccups in the mainline supply chain.

4. Counterfeiting of products and services.

5. Deforestation

MOTIVATIONS

TQM - IOT ENABLED SUPPLY CHAINS ELIMINATE WASTE

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GRATITUDE

When did I learn to take on what I did not know I did not know?

Nothing was created in a vacuum

OK – Maybe quantum fluctuations of all of the particles we know – AND the UNIVERSE, but …

OK – I never created anything without an abundance of curiosity – and helpful people.

Helpful People

CALTECH - **Dr. Jesse L (Jack) Beauchamp** – who came to Caltech with an exciting new technology, Ion Cyclotron Resonance Spectroscopy (for studying chemical reactions in the gas phase). He not only listened to my crazy ideas, but he also encouraged me to implement them. One such idea, Ion Cyclotron Double Resonance resulted in a peer reviewed publication and won me two important awards. This was probably what got me into grad school.

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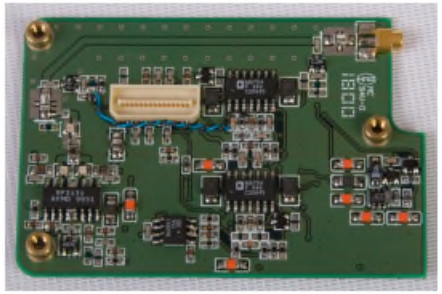
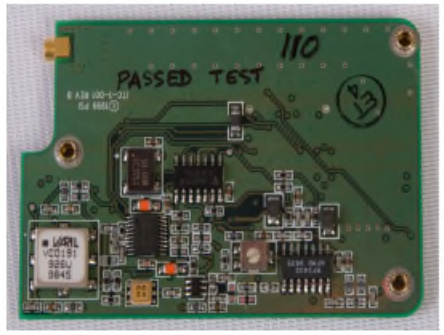
George W Stroke (SUNY Stony Brook) Holography and Coherent Optics (1971) Imaging through Distorting Media Synthetic Aperture Imaging Deblurring Photographs.		Real Time Location Systems **Marine Sciences Research Center** Loran A Loran C ADF (Automatic Direction Finding) Ocean Applied Research
TELEMETRY SYSTEMS, TRACKING, RFID		
Radio, Radar, Miss Distance Measurement, PLL's, Signal Coding, Modulation and Demodulation… Doppler Radar Calibrator (Bleeper): diode across a dipole modulated at audio (doppler) frequency. Ranger: S-Band Passive Acoustic Sensor with range gated Direct Sequence Interrogator. 1 meter range gate (Chipping rate 350MBps)		**RESDEL ENGINEERING CORP** **(A Division of RESDEL INDUSTRIES)** (1974-1985, 1986-1989) Don A. Boesch John Richert Earl Mathisen John LeNorman Greg Noneman Skip Schmidt Gordon Larson Malcom Brown Tom Barnett **And Many, Many more**.

Spread Spectrum in Depth Gould Navcom (1986-1988) **Dr. Robert Gold** (of “Gold Codes” fame) **Terry Flach**		RADIO SCIENCE **Dr. A. J. (Jack) Mallinckrodt** NORAND **Pat Kinney** **Ron Mahany** **Denny Durbin** **Robert (Bob) Dixon**
RFID – Kipp, Intermec **PROBE** SCIENCE, INC. (1989 – 2016) **P**osition **R**eporting **O**n **B**ackground **E**mission Alan Meghrigian John Richert Aurelio (Jun) Reyno Cenon (Cen) Reyno Terry Flach Allen Hollister Gary Barta		RFID Companies Co-Founded (2000 – Present) **TiM** (Tagged Information Management Systems) **IDentifi** * **Senitron** * **RF Accelerated** (Acquired IP from IDentifi) * **MonsoonRF** * **ZipChannelRF** (* indicates still operational)

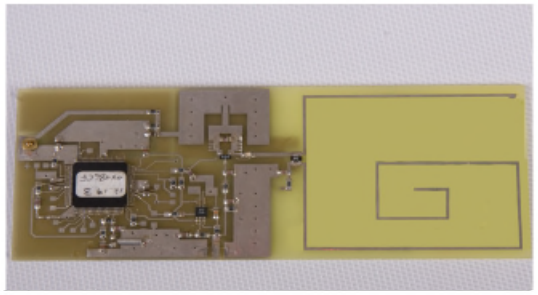
EARLY RETAIL RFID SYSTEM DEVELOPMENT
1995 - 2000

HANDHELD RFID READER—1999
NORAND - INTERMEC
FOR THE IBM INTELLITAG





QFAST™ RFID TAG PROTOTYPE
KIPP RETAIL INFORMATION SYSTEM



(12) **United States Patent**
Armstrong et al.

(10) **Patent No.: US 7,626,488 B2**
(45) **Date of Patent: Dec. 1, 2009**

(54) **METHOD AND SYSTEM FOR COMMUNICATING WITH AND TRACKING RFID TRANSPONDERS**

FOREIGN PATENT DOCUMENTS

DE 196 52 324 A1 6/1998

(Continued)

(76) Inventors: **John T. Armstrong**, 297 S. Roosevelt

Primary Examiner Edwin C Holloway III

Connor

Related U.S. Application Data

(63) Continuation of application No. 09/726,136, filed on Nov. 29, 2000, now Pat. No. 7,253,717.

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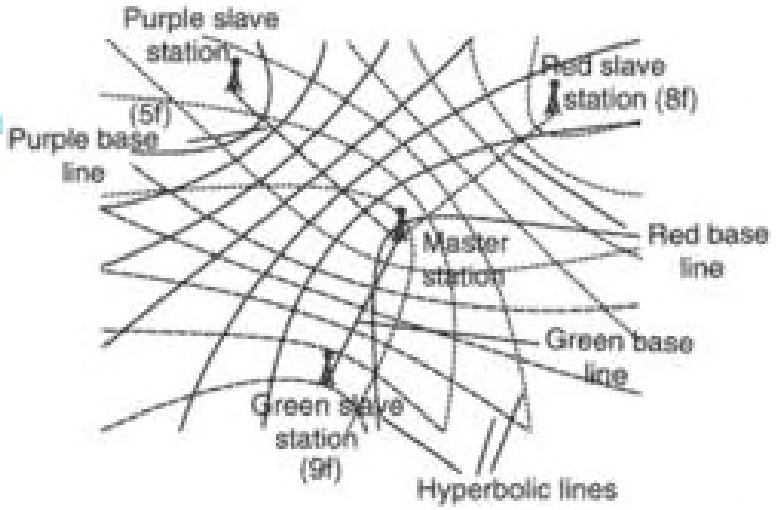
loran ['lȯr,an]

(navigation)

The designation of a family of radio navigation systems by which hyperbolic lines of position are determined by measuring the difference in the times of reception of synchronized pulse signals from two or more fixed transmitters. Derived from long-range navigation.

LORAN (long-range navigation)

A radio navigation system operating in an LF (low frequency) band. It utilizes master and slave stations transmitting timed pulses. The time difference between receptions of pulses from several stations establishes a hyperbolic position line, which may be identified from a LORAN chart. A fix can be obtained by drawing two hyperbolic position lines. LORAN A operates in the 1750 to 1950 kHz frequency band, while LORAN C operates in the 90 to 110 kHz frequency band.



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PORTABLE DOPPLER SIMULATOR
RESDEL MODEL 91997

DATA SHEET
383

World's Earliest RFID Tag

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Superpower

CURIOSITY

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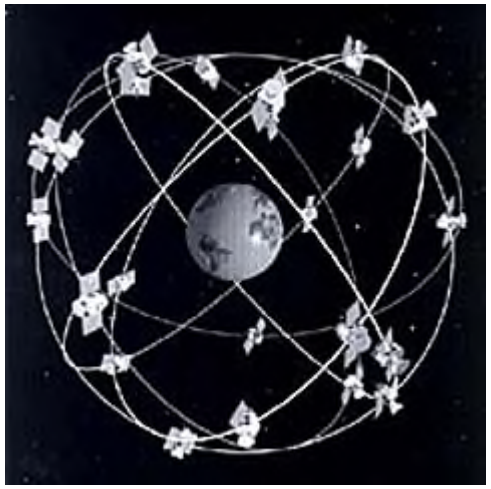
GLOBAL POSITIONING SYSTEM 1978

Block I satellites[edit]

Rockwell International was awarded a contract in 1974 to build the first eight Block I satellites. In 1978, the contract was extended to build an additional three Block I satellites. Beginning with Navstar 1 in 1978, ten "Block I" GPS satellites were successfully launched. One satellite, "Navstar 7", was lost due to an unsuccessful launch on 18 December 1981.[3]

I WANT TO KNOW NOW!



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Footnotes – Loran A and Loran C

- *LORAN A operated at either 1.85MHz or 1.95MHz and LORAN C operated at 100 kHz. LORAN A used a simple shaped pulse and LORAN C used a modulated pulse. In both, the location of a receiver capable of picking up the Master and one or more slaves, could find it is location by first noting the time differences between the pulses and knowing the exact location of each transmitter. For those of you mathematically inclined, the locus of points with a constant time difference is a hyperbola, and the set of hyperbolas for at least three transmitters was sufficient to locate the receiver. With a little work, these systems provided accuracies of a few hundred feet.*

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Choose Constraints Wisely

POSITION REPORTING ON BACKGROUND EMISSION
1978

WHERE IS MY CAR?

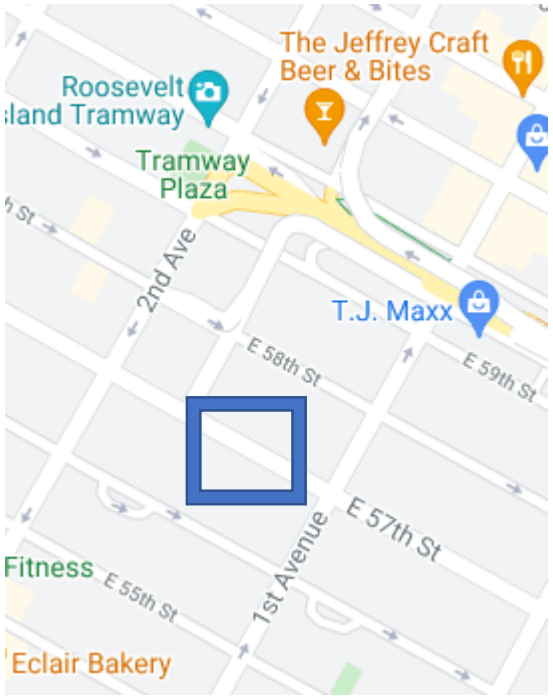
NYC

WHERE IN NYC?

ON A STREET OR AVENUE

CAN YOU BE MORE SPECIFIC?

E. 57TH AVE. BETWEEN 1ST ST. AND 2ND ST.



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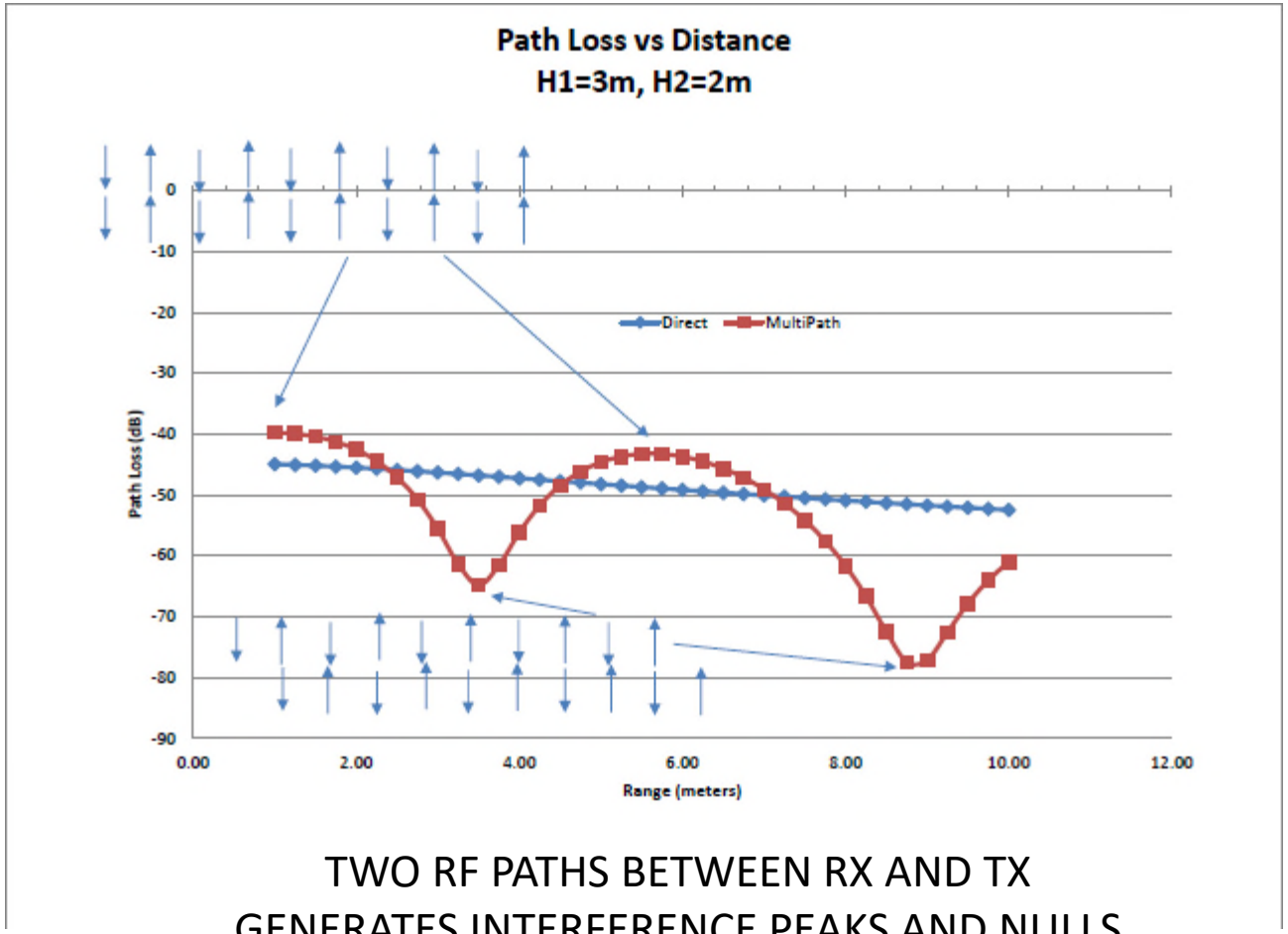
BASIC MULTIPATH “RANGE PROBLEM”



TWO RF PATHS BETWEEN RX AND TX
GENERATES INTERFERENCE PEAKS AND NULLS
COMPARED TO FREE SPACE – MANY dB

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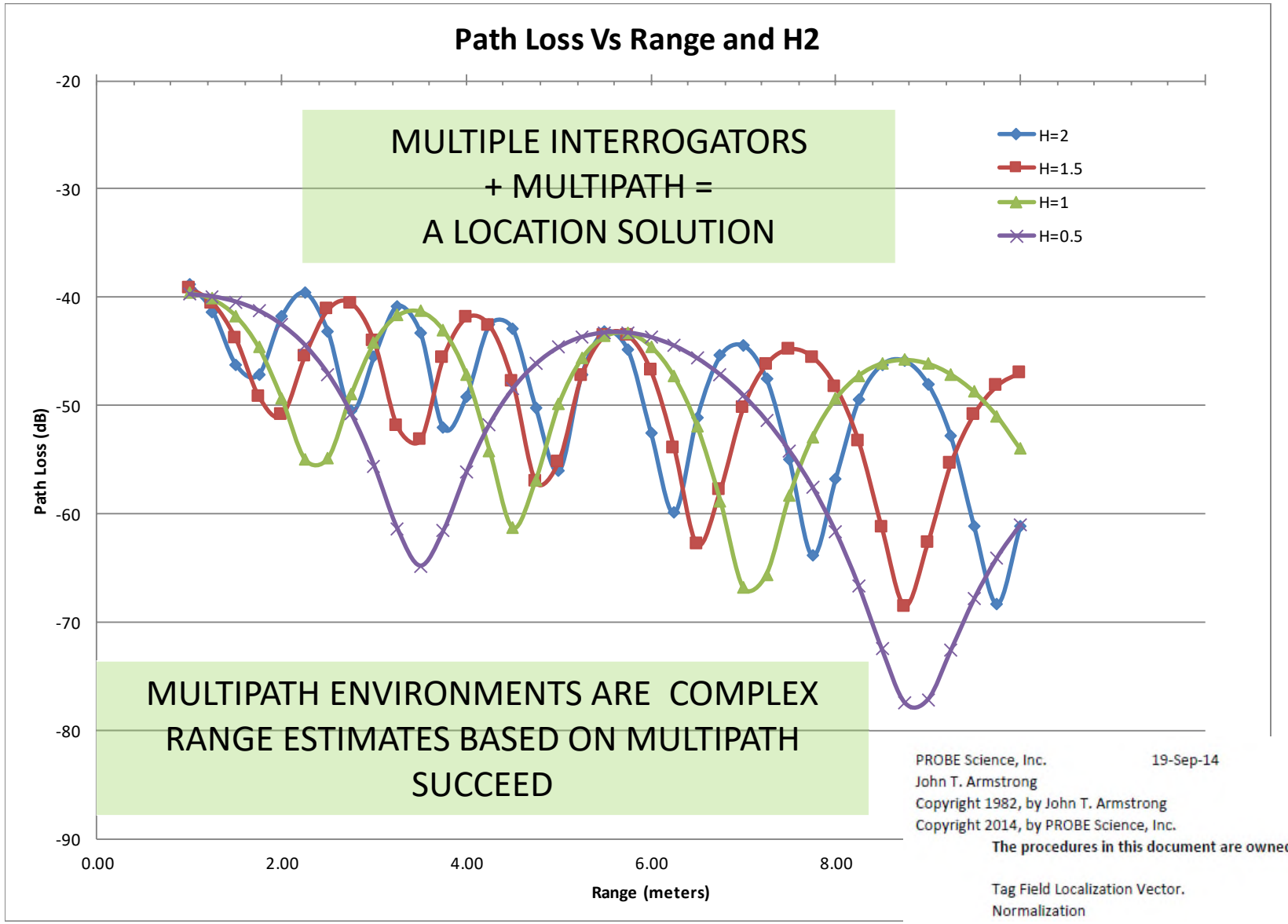

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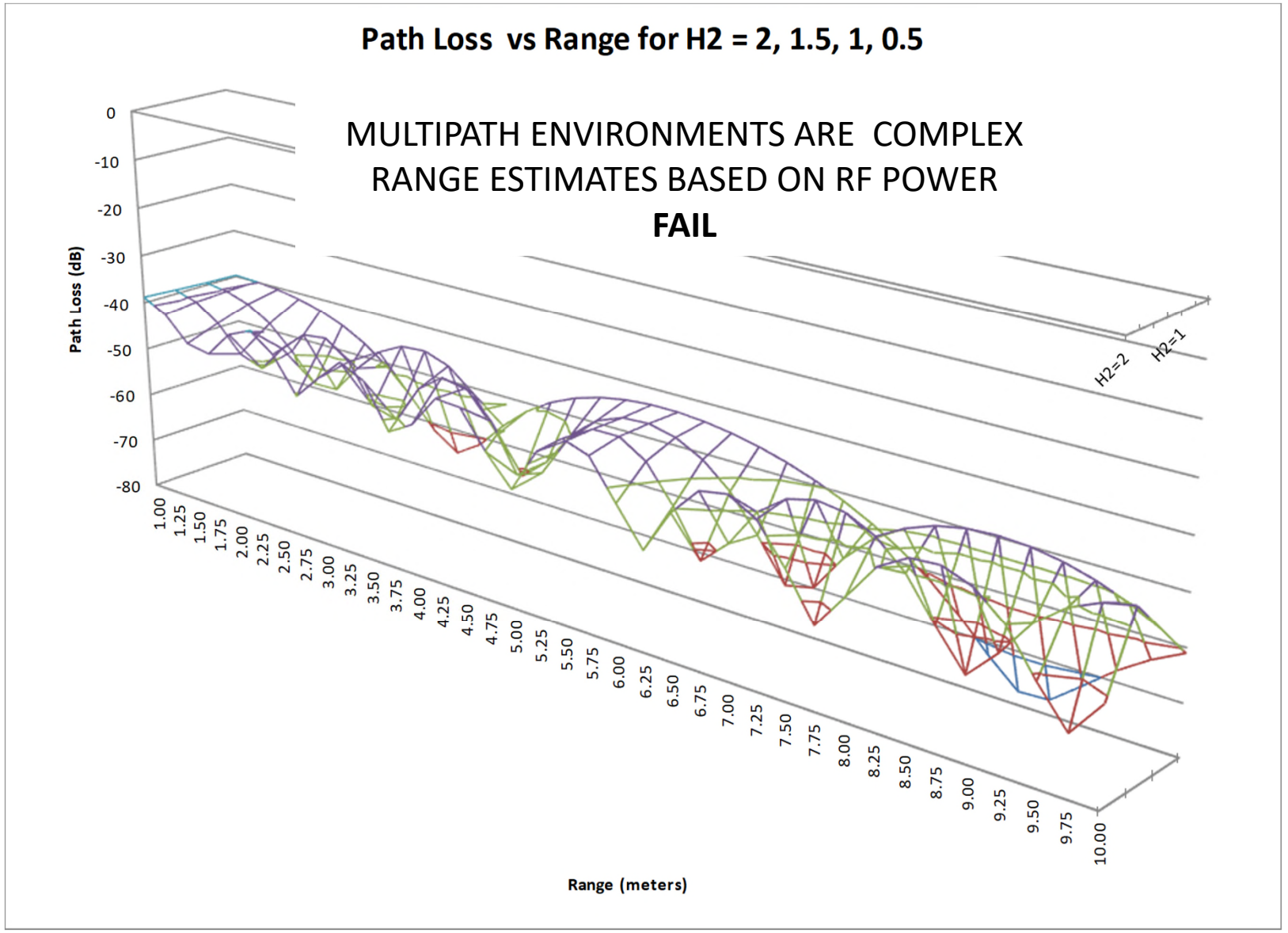

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THE ERA OF ELECTRONIC CHECKOUT - SKU

HOW MANY OF YOU ARE THERE?

I THINK YOU DOUBLE COUNTED.

HOW DO I KNOW YOU DIDN'T DOUBLE COUNT?

DO IT AGAIN.

STOCK COUNTING UNIT (SKU) – NO DIFFERENCE BETWEEN 1 AND 100 OF THE SAME ITEM.

ELECTRONIC PRODUCT CODE (EPC) AND RFID

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DON’T SHOUT OUT

ALOHA

SLOTTED ALOHA

EPC GEN2 SLOTTED ALOHA – MEET MR. Q

FIREHOSES AND FAUCETS

TAG OPPORTUNITY COST THRESHOLDS – MEET DR. No.

CAN I CALL YOU?

WHAT IS YOUR NAME AND NUMBER?

PLEASE REPEAT – I DIDN’T HEAR YOU.

I’LL SELECT YOU, NEXT TIME. PROMISE.

OPPORTUNITIES FOR IMPROVEMENT

THE 10 MILLION TAG STORE.

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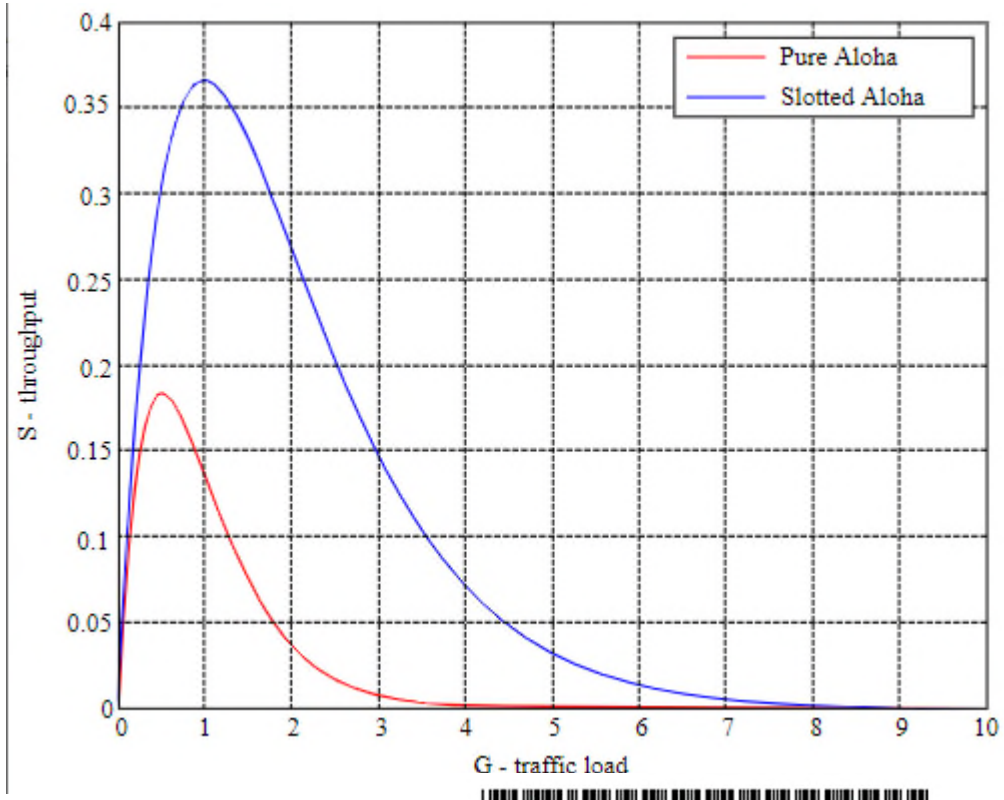
https://en.wikipedia.org/wiki/ALOHAnet

Slotted Aloha Channel Capacity



(12) **United States Patent**
Hollister et al.

(10) **Patent No.: US 10,063,515 B2**
(45) **Date of Patent: Aug. 28, 2018**

(54) **METHOD OF COMMUNICATING IN A RADIO FREQUENCY IDENTIFICATION SYSTEM USING ALOHA NETWORKS**

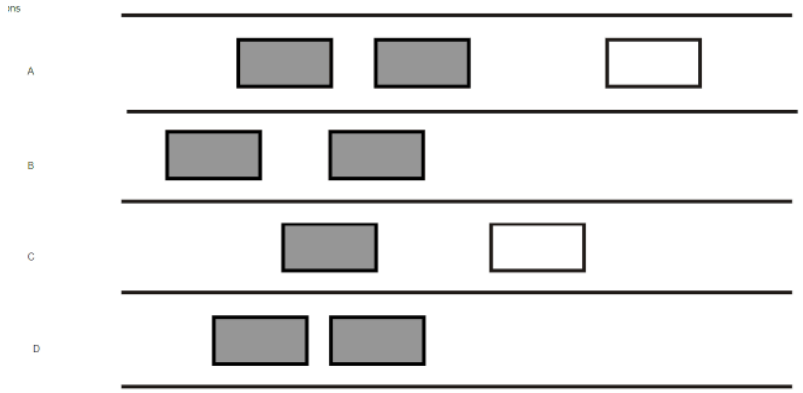
(76) Inventors: **Allen Hollister**, La Habra, CA (US); **Gary Barta**, Duarte, CA (US); **John T. Armstrong**, Pasadena, CA (US)

2007/0085661 A1*	4/2007	Yamazoe et al.	.....	340/10.1
2007/0096877 A1*	5/2007	Quan et al.	.....	340/10.2
2007/0126555 A1*	6/2007	Bandy	.....	340/10.2

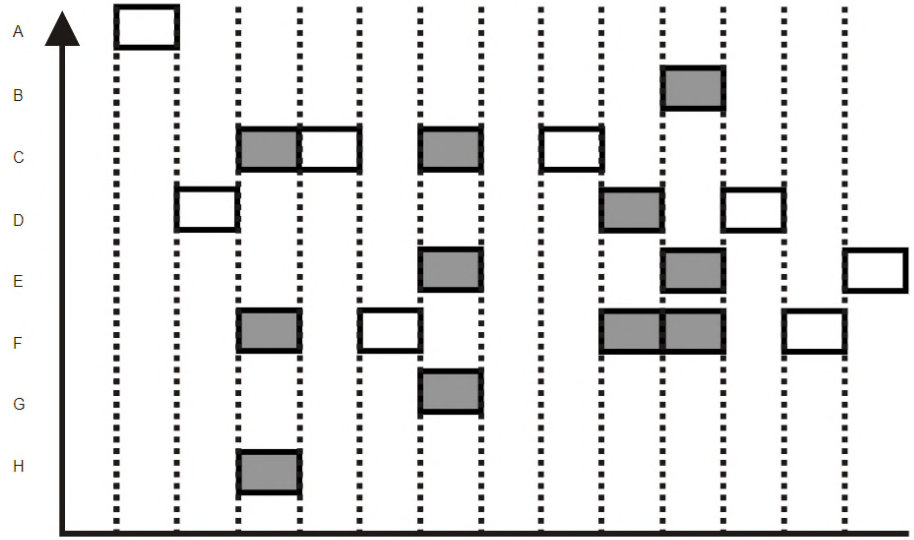
* cited by examiner

Primary Examiner — Steven Lim

Standard Aloha – lots of collisions



Time ➔



Slotted Aloha – EPC Gen2 has 2^Q slots

Slotted ALOHA protocol (shaded slots indicate collision)

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PROGRESS ON READING HIGH TAG DENSITIES

(12) **United States Patent**
Armstrong et al.

(10) **Patent No.: US 7,626,488 B2**
(45) **Date of Patent: Dec. 1, 2009**

(54) **METHOD AND SYSTEM FOR COMMUNICATING WITH AND TRACKING RFID TRANSPONDERS**

(76) Inventors: **John T. Armstrong**, 297 S. Roosevelt Ave., Pasadena, CA (US) 91107; **John D. Richert**, 460 Avocado Crest Rd., La Habra Heights, CA (US) 90631; **John P. Palmer**, 480 Portafino Ct., Apt. 203, Pomona, CA (US) 91766

FOREIGN PATENT DOCUMENTS

DE 196 52 324 A1 6/1998

(Continued)

Primary Examiner—Edwin C Holloway, III
(74) *Attorney, Agent, or Firm*—Christensen O'Connor Johnson Kindness PLLC

(57) **ABSTRACT**

The original Kipp Retail Information System Patent contains approaches which can still offer enhancement to slotted aloha

Some of these have been collected and thrown into the 'kitchen sink' of a large collection of accessible orthogonal sorting techniques.

(12) **United States Patent**
Hollister et al.

(10) **Patent No.: US 10,817,679 B2**
(45) **Date of Patent: Oct. 27, 2020**

(54) **MULTIDIMENSIONAL SIEVING FOR HIGH DENSITY LOW COLLISION RFID TAG FIELDS**

(76) Inventors: **Allen Hollister**, La Habra, CA (US); **Gary Barta**, Duarte, CA (US); **John T. Armstrong**, Pasadena, CA (US)

OTHER PUBLICATIONS

Rohatgi, A. and Durgin, G.D, "Implementation of an Anti-Collision Differential-Offset Spread Spectrum RFID System", Jul. 9-14, 2006, Antennas and Propagation Society International Symposium, p. 3501-3504.*

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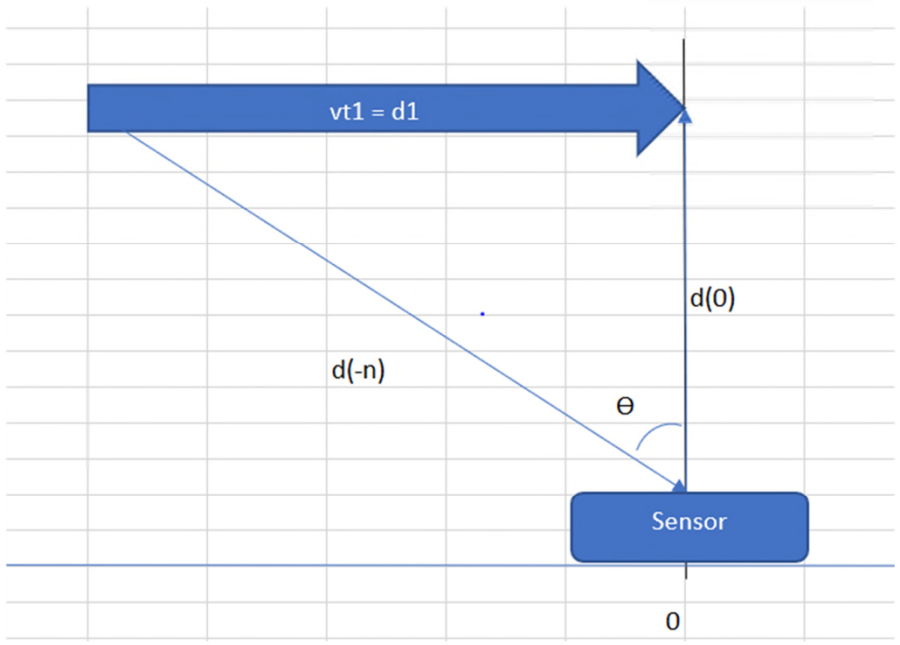
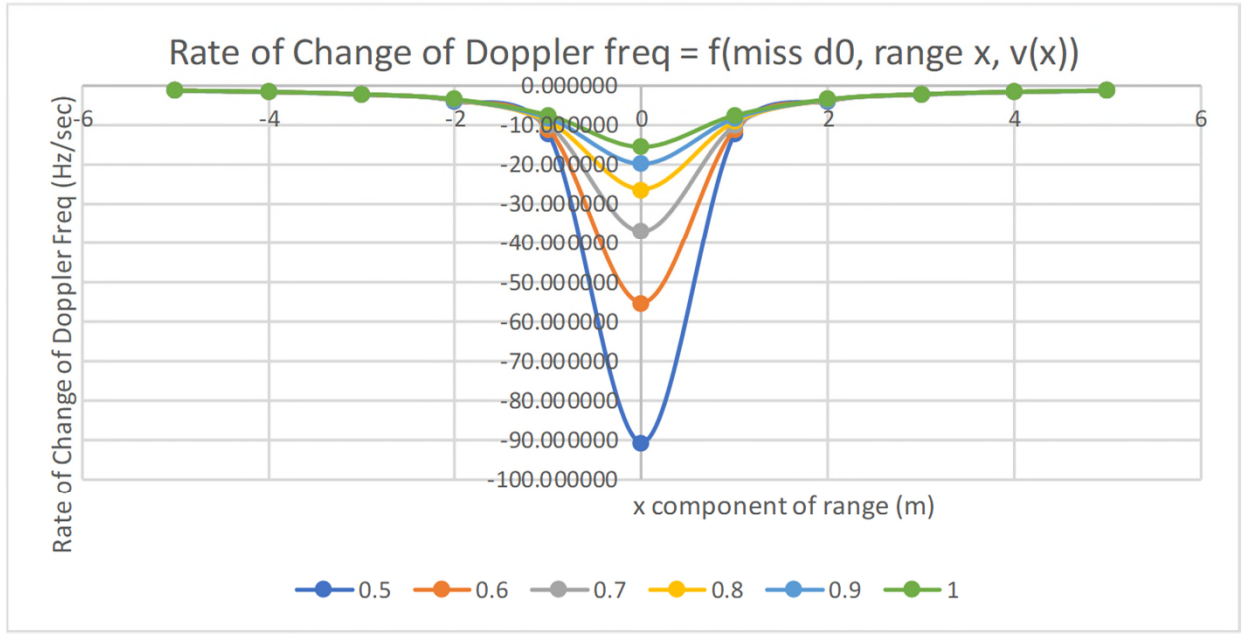
DETECTING MOTION, MINIMUM RANGE, AND VELOCITY WITH DOPPLER

The basic RFID Interrogator is a monostatic radar – with a single antenna used for transmit and receive.

It can measure velocity of the tag relative to its location and make a measurement of miss distance using the rate of change of the measured doppler frequency as shown below.





The vertical scale is in Hz/sec and the traces represent miss distances in meters. In this example, a single sensor using a frequency of 915 MHz will easily estimate movement through a standard 36-inch door at a walk.

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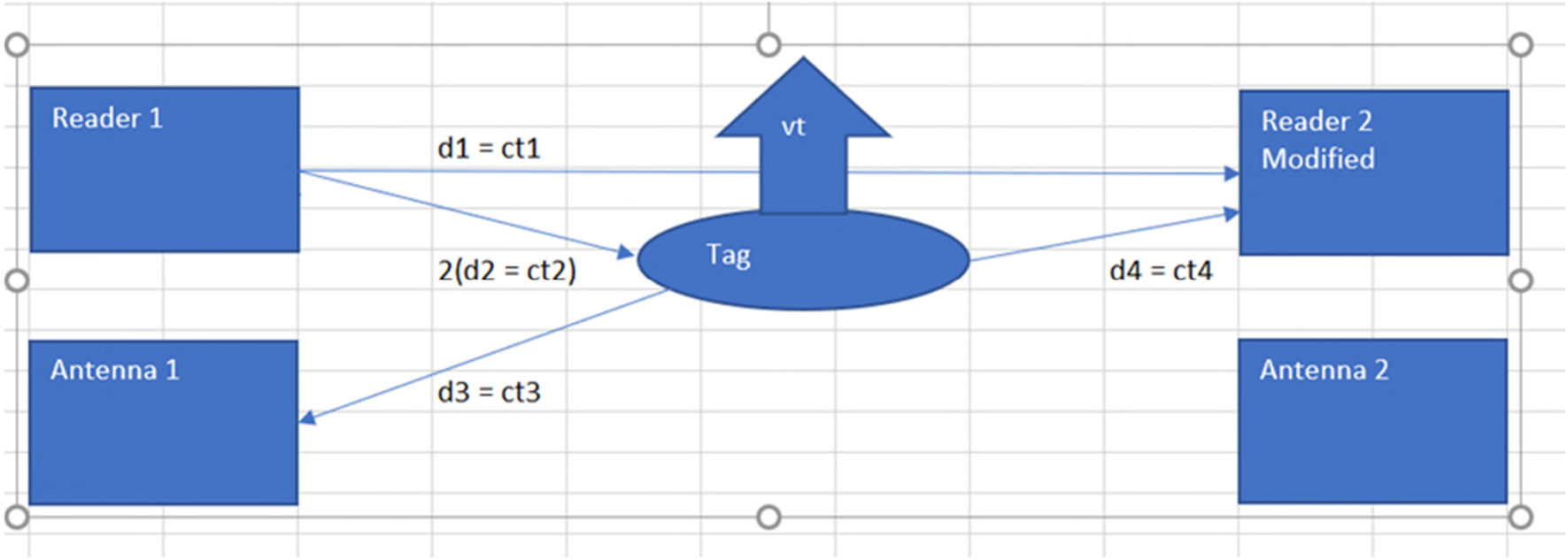
DETECTING MOTION, LOCATION, AND VELOCITY WITH DOPPLER

A bistatic radar implementation can yield another measurement of position and velocity, providing another dimension for measuring location and velocity of a moving tag.



In the figure above, Reader 2 has been modified to allow a direct signal d1 from Reader 1 to demodulate the forward scatter from the Tag (d2 +d4) as well as the monostatic 2 x d2 path. If reader 2 is used with Antenna 1 in a bistatic arrangement, we get a solution for d2+d3, and if Reader 1 operates through Antenna 1 in a monostatic configuration we solve for 2 x d3. In any event, knowing the real distance (fixed Reader installation) gives us a real value for d1 and for the distance between Reader 1 and Antenna 1. In this way, we obtain independent measurements of position.

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LAST SLIDE
Q & A

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Thank You

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AGING OUT

IM SORRY – WHO ARE YOU AGAIN?

I DON’T REMEMBER YOU.

HAVE I MADE YOUR ACQUAINTANCE?

HOW DID YOU GET MY NUMBER?

I DO KNOW YOU.

I WROTE YOUR NAME DOWN IN MY LITTLE BOOK.

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