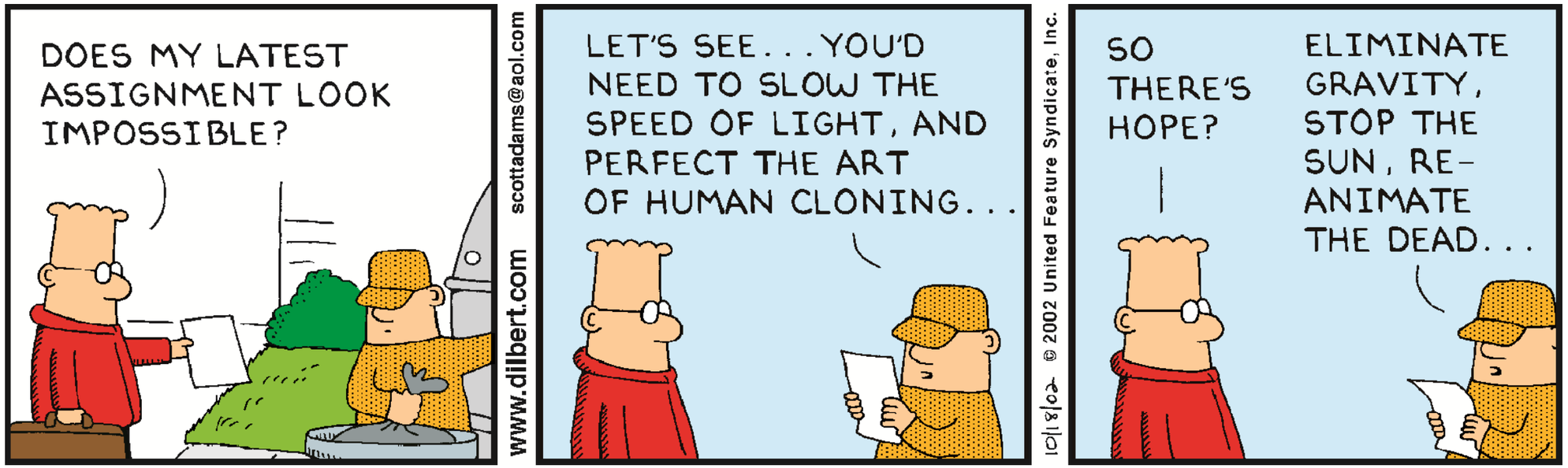
Connecting the **FUTURE:** *It's a Wireless World*

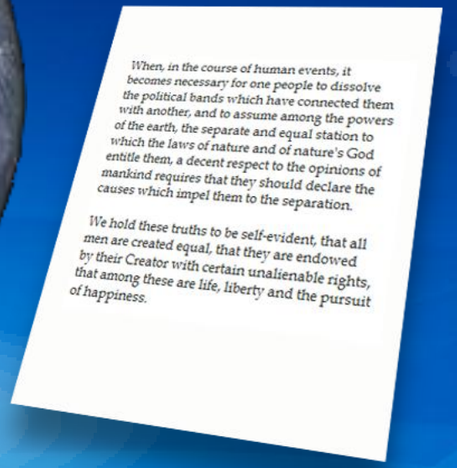
The Latest Research From **Intel Labs**


IN THE FUTURE
EVERYTHING THAT COMPUTES
CONNECTS



IDF February 2002

It's an ANALOG WORLD!



Analog is how we interact with the real world – but the technology favors digital

The Trouble with Analog

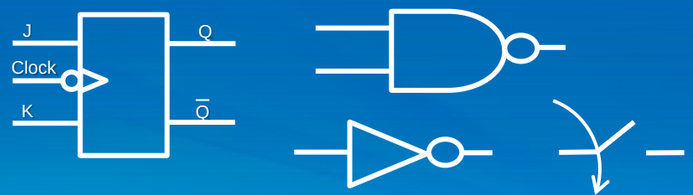
ANALOG RF DESIGN

Size: 100s of µm

Inductors, OpAmps…

- Does not scale well w/ CMOS
- Requires mature process

DIGITAL DESIGN



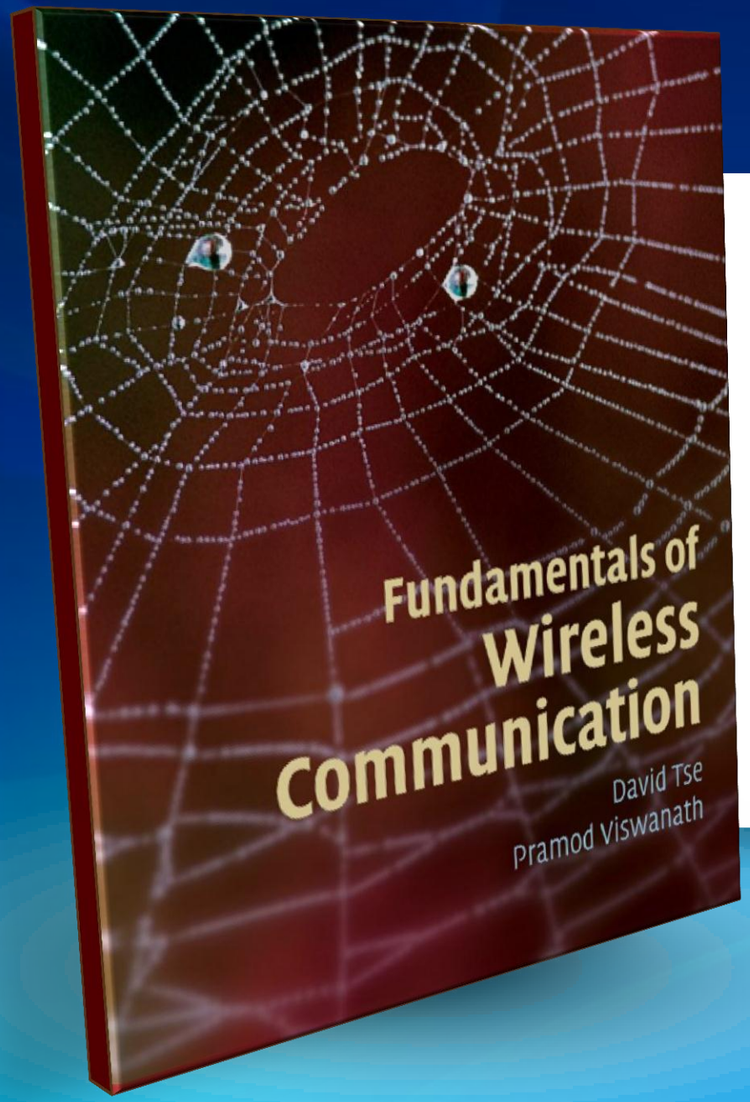
Size: 10s of nm

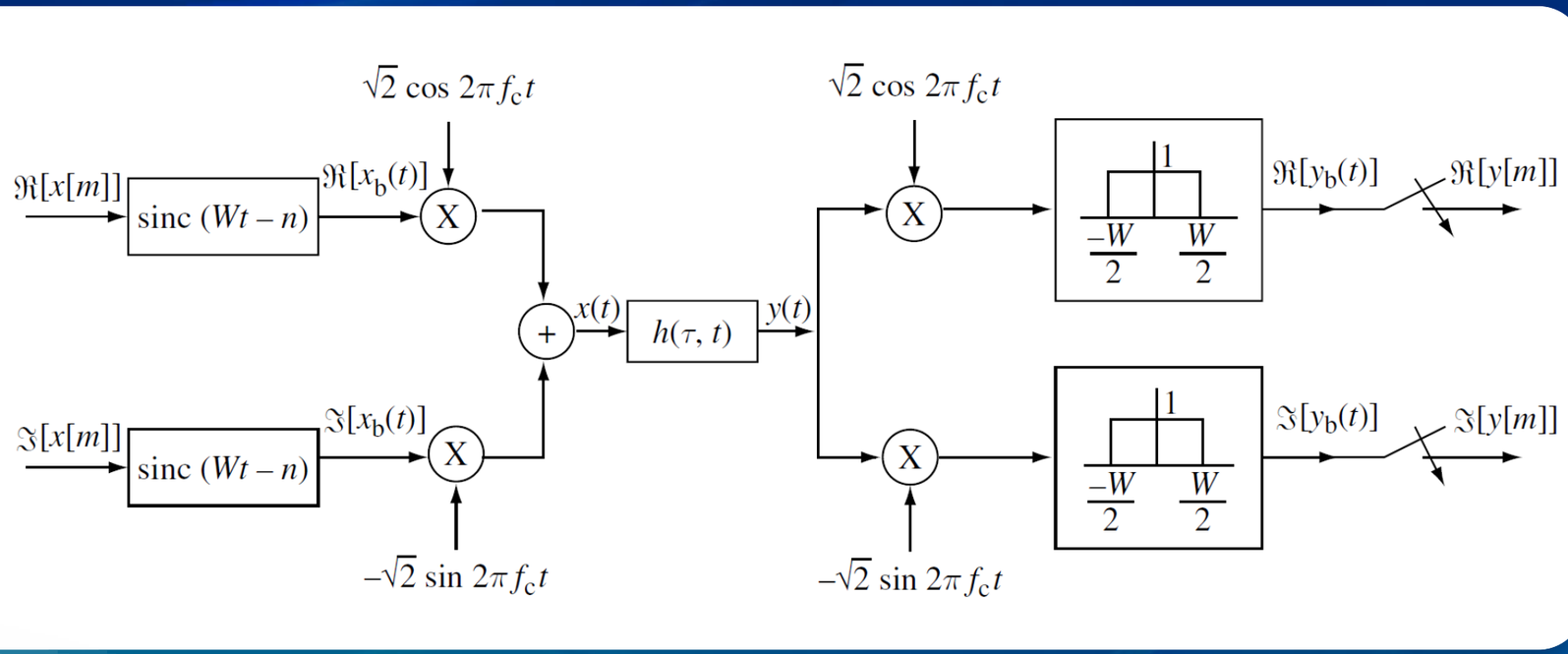
Inverters, Gates, Latches…

- Better/smaller every CMOS generation

While digital blocks continue to shrink, analog hardly shrinks at all

Communication is All Math



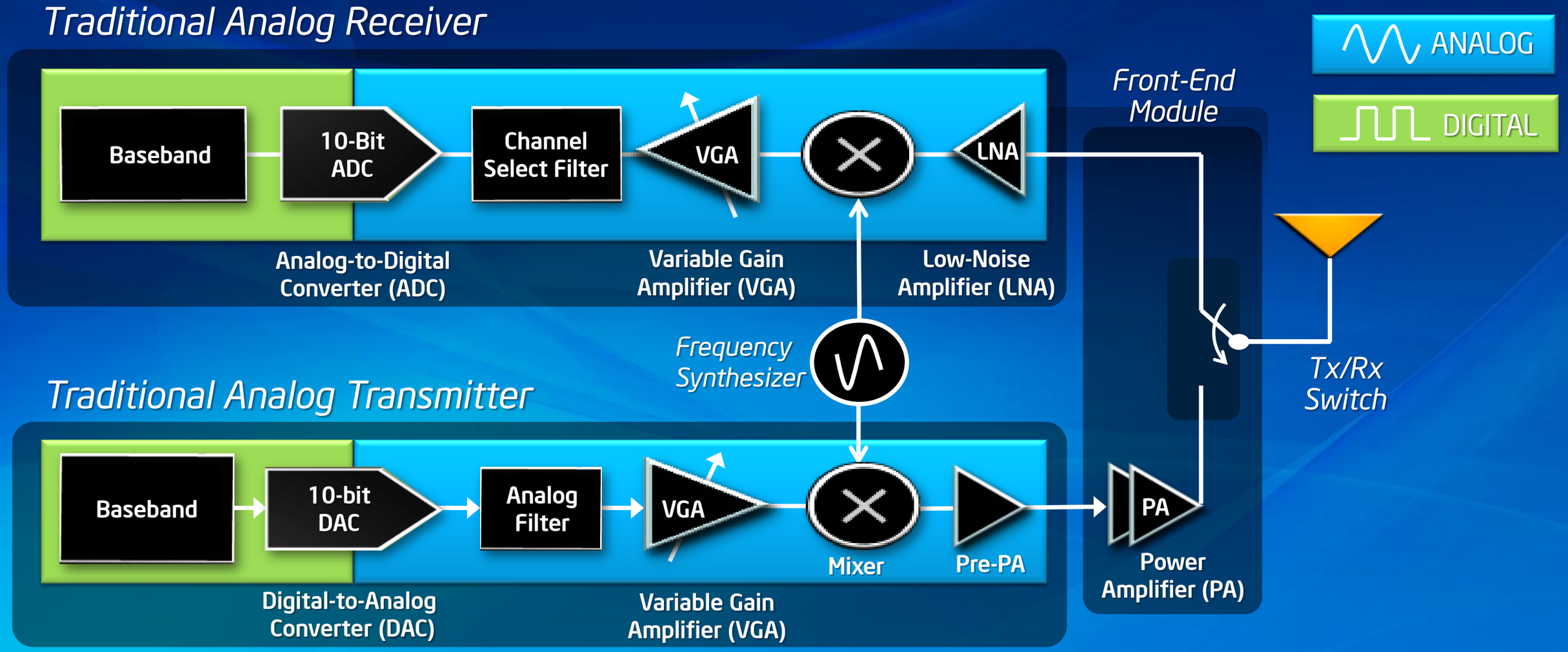


Mathematical systems diagram of baseband radio transmission

Yorgos Palaskas
Research Leader
Radio Integration Lab
Intel Labs

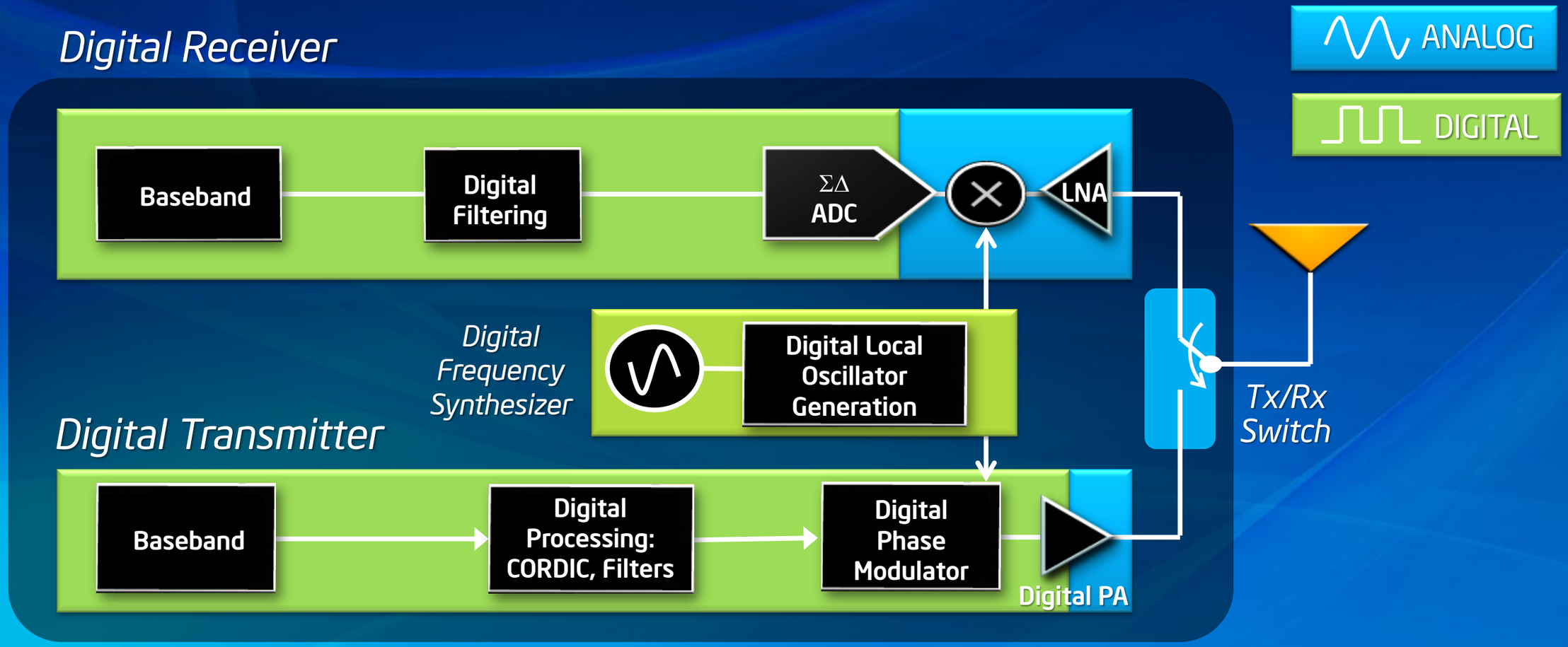
Traditional Analog Radio Design

A mix of passive and active analog devices



Vision for a Digital Radio

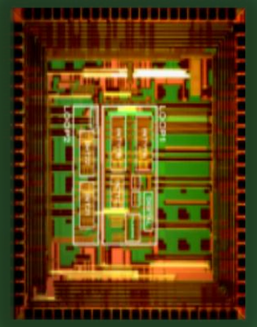
Exploiting the Computational Nature of Radio



Paving the Path to a

DIGITAL RADIO

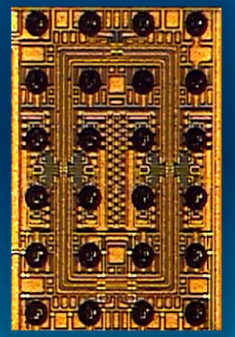
RECEIVER



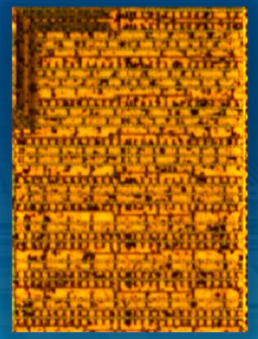
Sigma Delta ADC

Digital Frequency Synthesizer

TRANSMITTER



Digital RF Power Amplifier

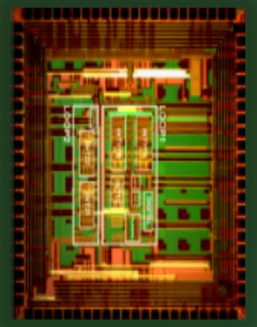


Digital Phase Modulator

Paving the Path to a

DIGITAL RADIO

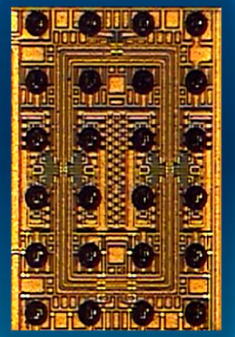
RECEIVER



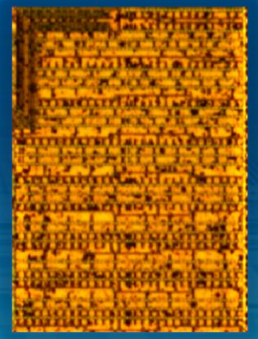
Sigma Delta ADC

Digital Frequency Synthesizer

TRANSMITTER



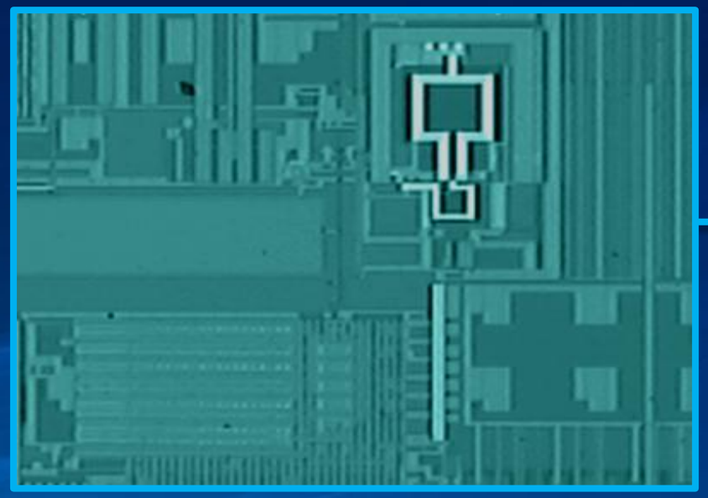
Digital RF Power Amplifier



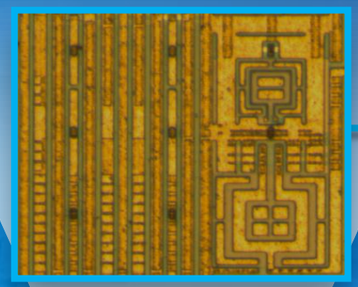
Digital Phase Modulator

Example of
Bringing the Benefits
of Moore's Law
to Radio

Fractional-N Digital Frequency Synthesizer



90nm
Area: 1.2mm²
Power: 50mW



32nm
Area: 0.3mm²
Power: 21mW

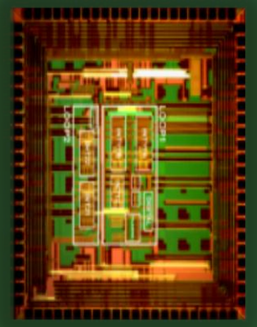
14nm*
Area: ~0.04mm²

* projected

Paving the Path to a

DIGITAL RADIO

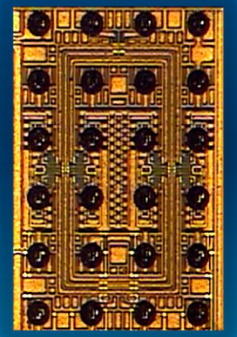
RECEIVER



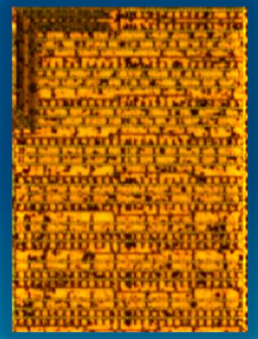
Sigma Delta ADC

Digital Frequency Synthesizer

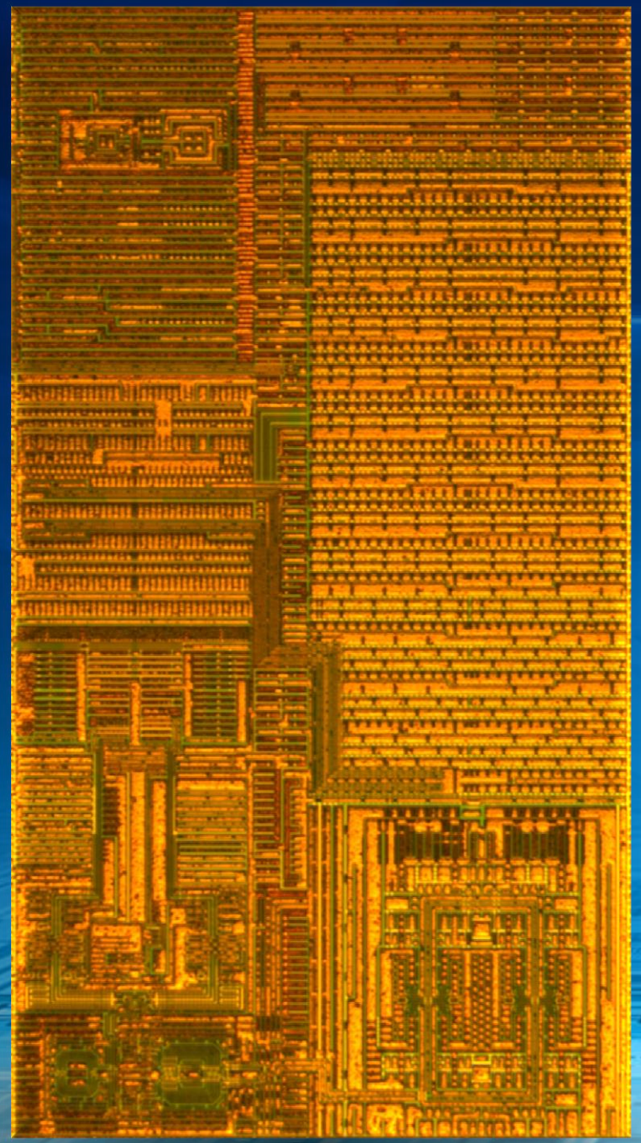
TRANSMITTER



Digital RF Power Amplifier



Digital Phase Modulator



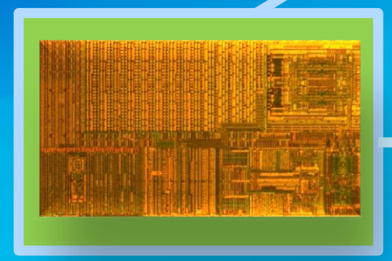
MOORE'S LAW RADIO

Digital RF Wi-Fi Transceiver

- First complete Wi-Fi digital radio
- With full 40MHz Wi-Fi bandwidth
- Built on Intel 32nm technology
- State-of-the-art power efficiency
- Performance improves with CMOS scaling

MOORE'S LAW RADIO DEMONSTRATION

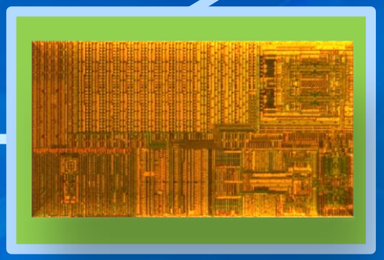
FPGA



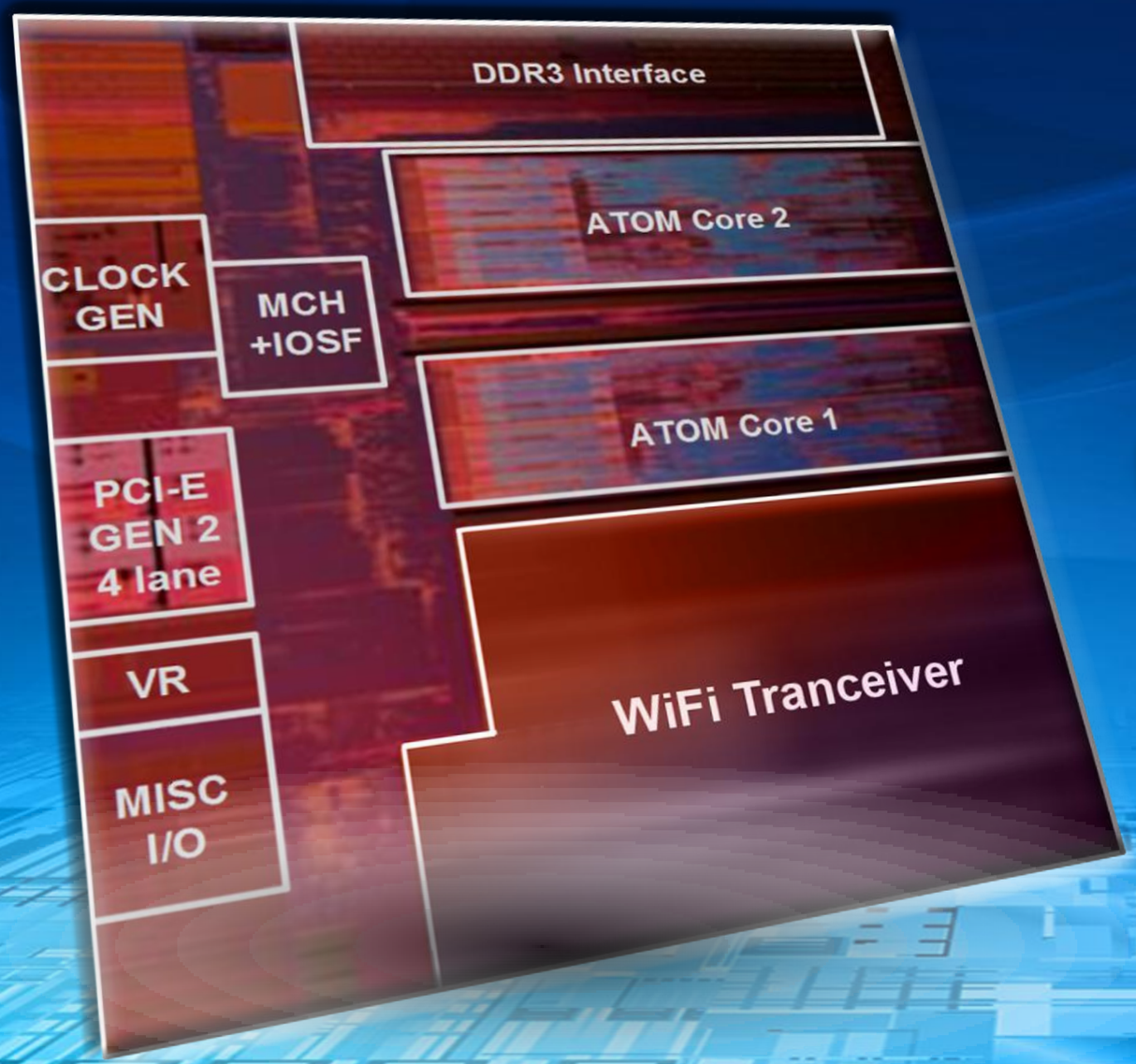
Moore's Law Radio
(receiver)

Wi-Fi 802.11g

FPGA



Moore's Law Radio
(transmitter)



ROSEPOINT:

Experimental 32nm SoC with WiFi transceiver and two Intel® Atom™ cores on the same die

Can Wireless Eliminate All Those

WIRES?

Ali Sadri

President of WiGig Alliance
Director mmWave Technology
Intel Corporation

Instant Wireless Sync

Wireless Docking

WiGig™

Wireless Gigabit Alliance

Wireless Display

Internet Access

Member Companies of the Wireless Gigabit Alliance

Board of Directors

AMD
Broadcom — Connecting everything
Cisco
Dell
Huawei
Intel
Marvell
MediaTek
Microsoft
NEC
NVIDIA
Panasonic
Qualcomm Atheros
Samsung
Toshiba
Wilocity — truly wireless

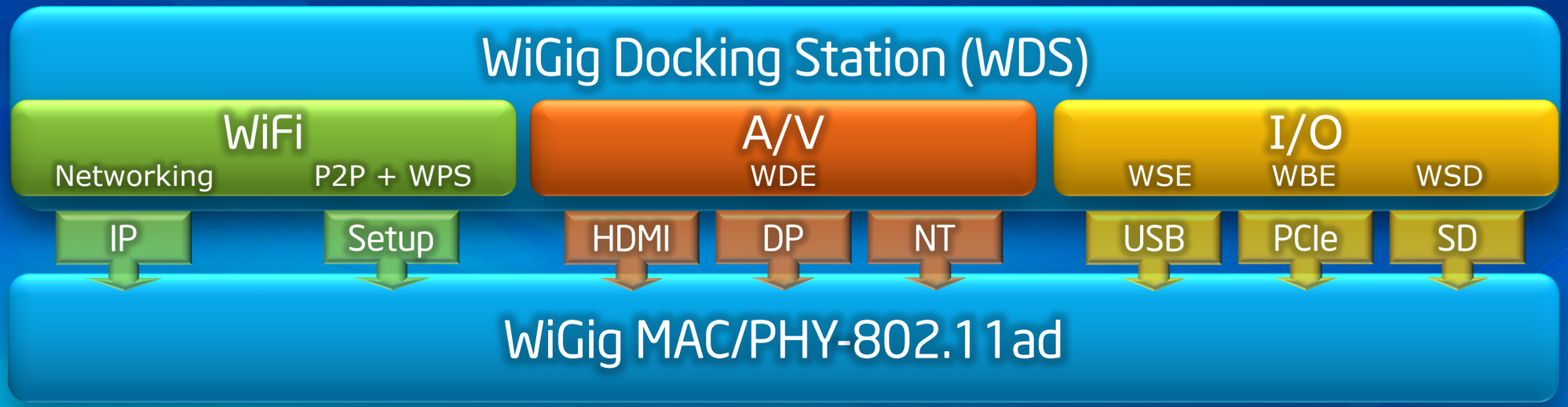
Contributors

Agilent Technologies
Alereon
Allegro — Digital Video Technology
Beam Networks
CSR
FTDI Chip
Harman
Hittite Microwave Corporation
A*STAR — Institute for Infocomm Research
LG Electronics
MET
NXP — founded by Philips
Peraso
Rohde & Schwarz
Samsung
Samsung Electro-Mechanics
Silicon Image
SRTC — The State Radio_monitoring_center Testing Center 国家无线电监测中心检测中心
ST
Texas Instruments
TMC
TÜVRheinland® — Precisely Right.
UL
ZTE中兴

WiGig™ Wireless Gigabit Alliance

For More Info Visit:
http://wigig.org

Wireless Docking with WiGig



Convenience vs. Battery Life

Does always-on and always-connected mean always recharging, too?

First Example of Always-On, Always-Connected PC

Intel® Smart Connect Technology

Appearance of constantly updated content while the system is asleep!

Gives Ultrabooks same functionality that's standard in phones & tablets

Charlie Tai
Principal Engineer
Intel Labs

Improving the Efficiency of

ALWAYS-ON, ALWAYS-CONNECTED

- Wireless interfaces frequently wake CPU to process traffic
- Large percentage of incoming traffic can be ignored
- Erratic traffic arrival times prevent extended idle

SPRING MEADOW TECHNOLOGY

Always-On, Always-Connected Without Compromise

MORE VIDEO STREAMS

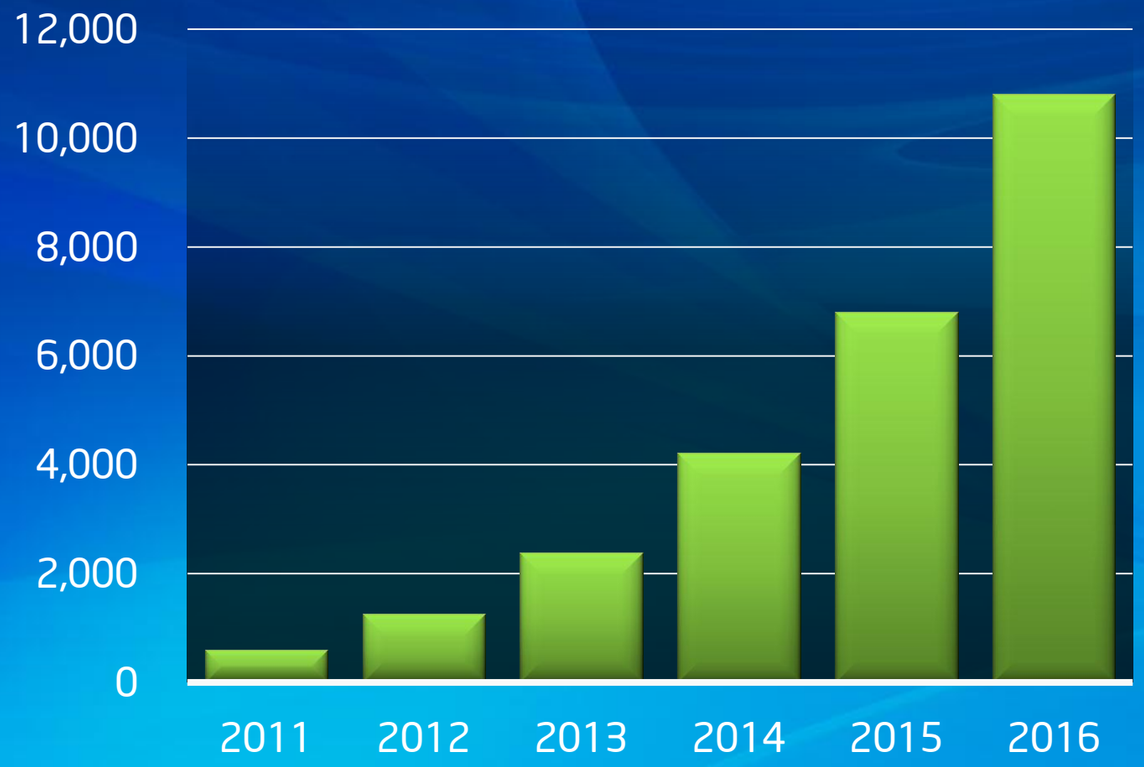
vs.

A BETTER VIDEO EXPERIENCE

Mobile and Video Traffic Are Exploding

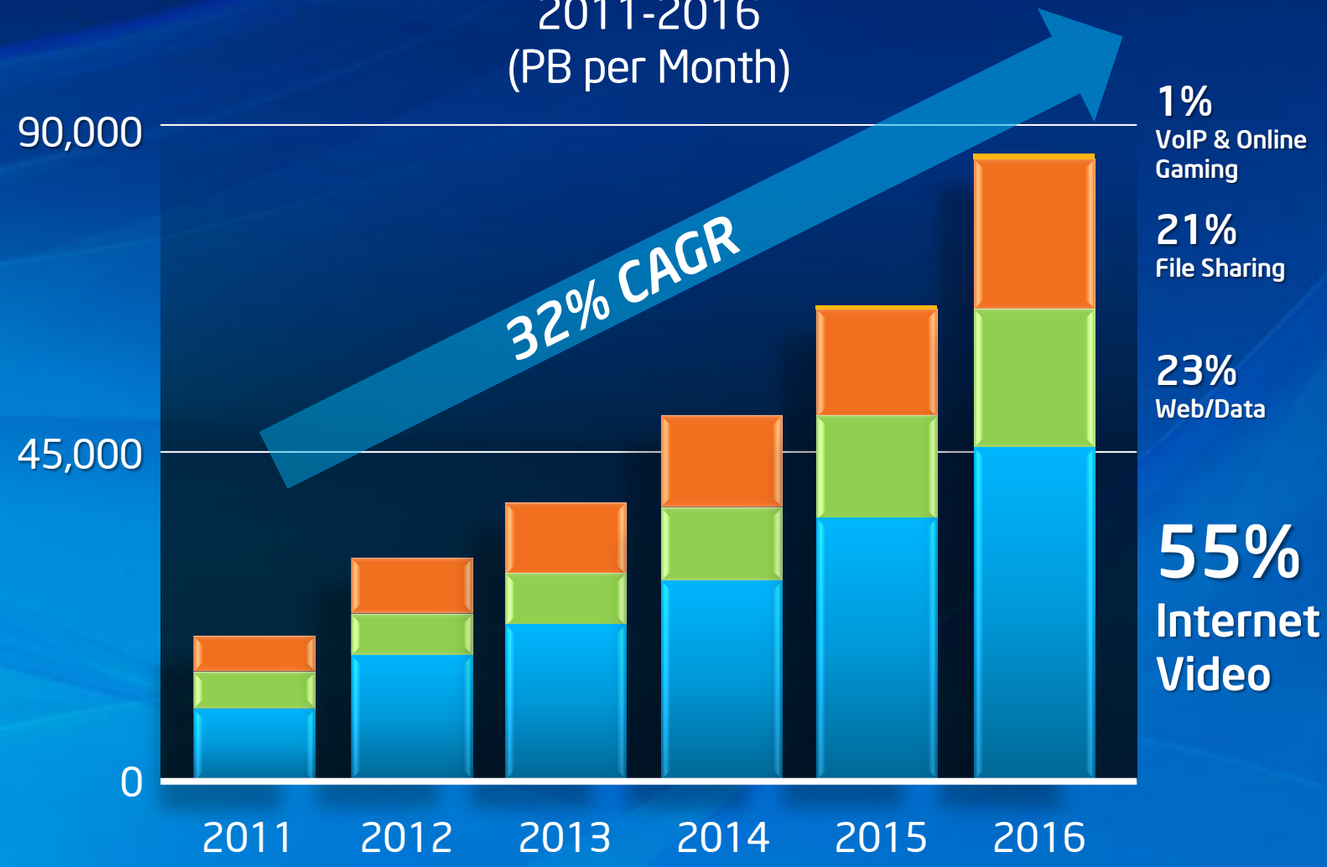
Mobile Data and Internet Traffic

2011-2016
(PB per Month)



Global Consumer Internet Traffic

2011-2016
(PB per Month)



Source: Cisco VNI Global Forecast. 2011 -2016

Chris Neisinger
Executive Director Network Planning
Verizon Wireless

Jeff Foerster
Principal Engineer
Intel Labs

Video Aware Wireless Networks (VAWN)

An Industry/University Research Collaboration

Optimized for Quality of Experience
with Real-time Adaptation

Device & Wireless
Network Aware

True QoE Adaptation

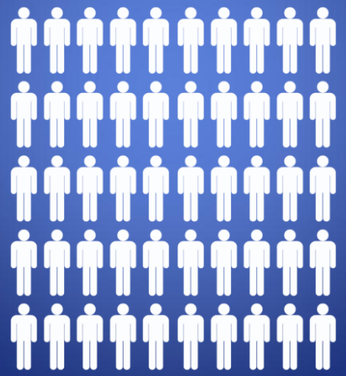
WIRELESS NETWORK

Device & Video
QoE Aware

Wireless
Video
Optimized

Video QoE
Aware

RESULT:
More High Quality
Video Streams to
More Users



intel · CISCO · verizon · UCSD · Cornell University Founded A.D. 1865 · USC University of Southern California · МГУ

Example of

Content-Aware Video Adaptation

10Mbps

Throughput-Managed Network

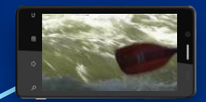
Equally Shared Bandwidth

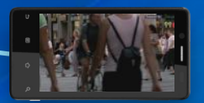
Example of

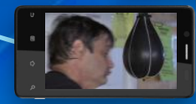
Content-Aware Video Adaptation

10Mbps

Video-Quality Managed Network







MORE VIDEO STREAMS *AND* HIGH QUALITY OF EXPERIENCE

EASE OF USE
VS.
INCREASED SECURITY?

Sridhar Iyengar

Director of Security Research
Intel Labs

Challenges of
MOBILE USER AUTHENTICATION

Too Many, Too Complex Passwords

Frequently Entering Passwords is Painful

Do We Have to Sacrifice Ease-of-Use for Security?

First Step to Improve Ease-of-Use:

Replace Passwords With BIOMETRICS

Secure Wireless Communications with Intel Labs'

CLIENT-BASED AUTHENTICATION TECHNOLOGY

Secure Wireless Communications with Intel Labs'

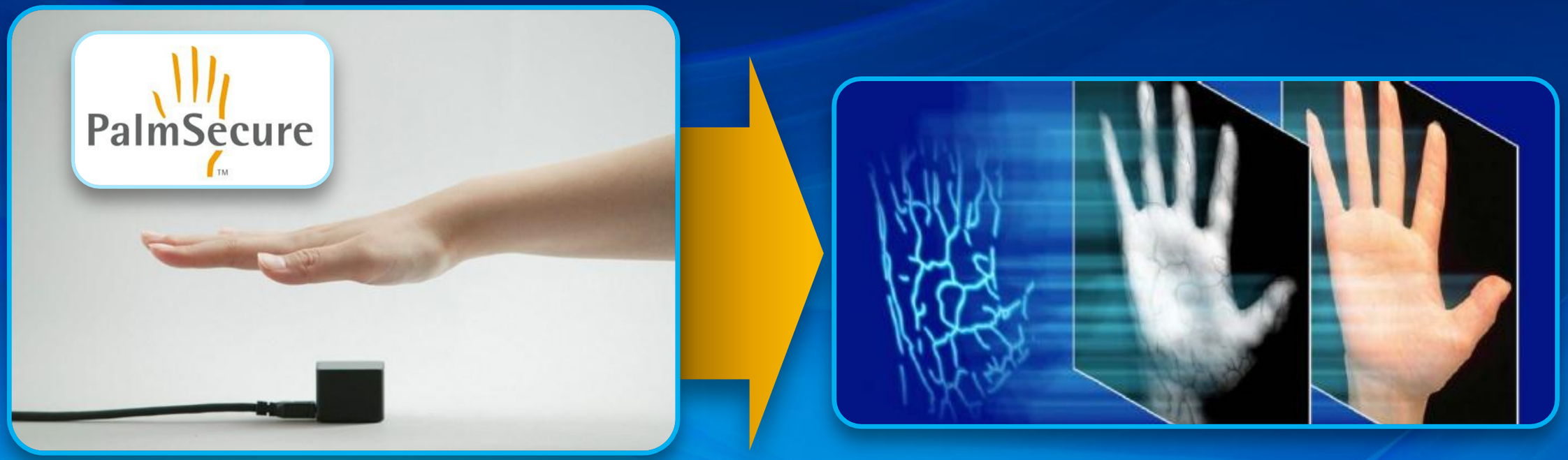
CLIENT-BASED AUTHENTICATION TECHNOLOGY

Secure Wireless Communications with Intel Labs'

CLIENT-BASED AUTHENTICATION TECHNOLOGY

Example Biometric Sensor for

AUTHENTICATION



Authenticates an Individual by Recognizing Unique Palm Vein Patterns

GREAT EASE-OF-USE
AND
IMPROVED SECURITY


Building the Next Generation
Wireless Infrastructure

At IDF 2011:

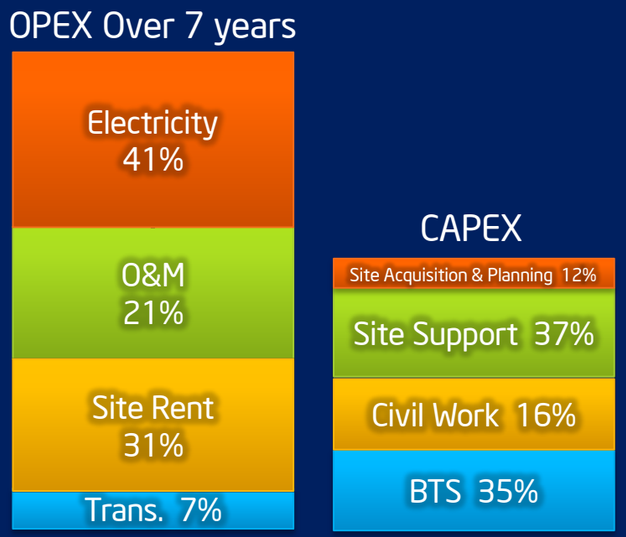
We Demonstrated an LTE Base Station on a PC Using a Software-Defined Radio

Dr. Chih-Lin I

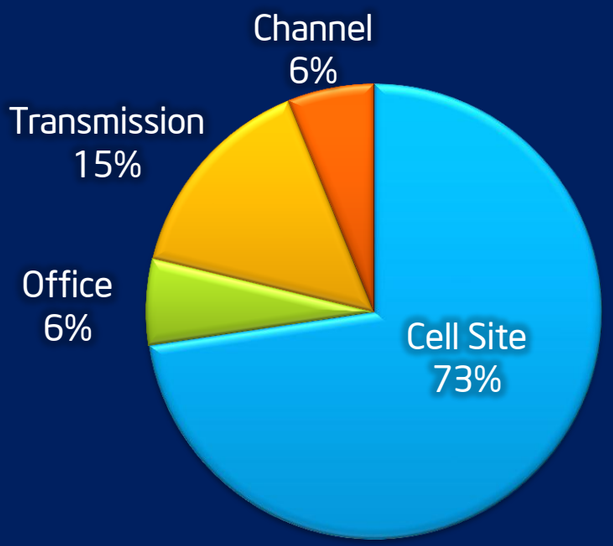
Chief Scientist
China Mobile Research Institute

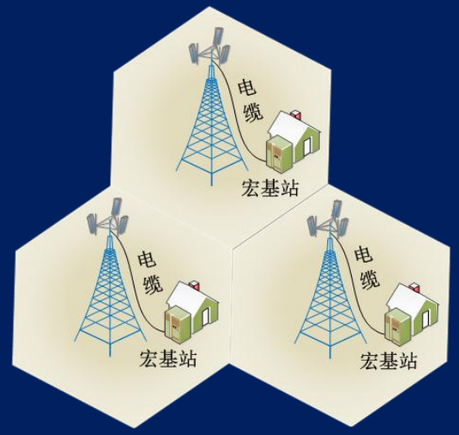
Challenges of Traditional
RADIO ACCESS NETWORKS

Basestation Cost Structure

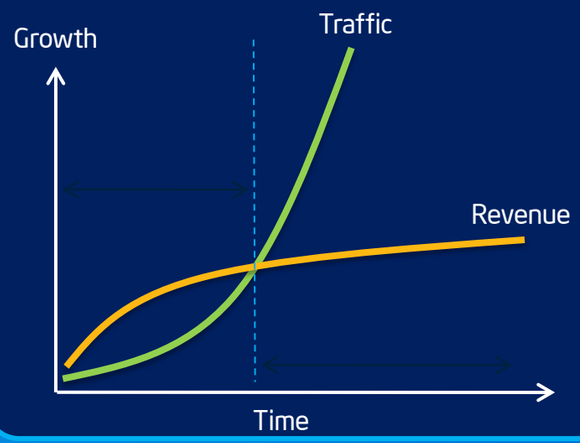


Power Consumption





Interference with Dense Deployment



Explosive Mobile Internet Traffic

Source: C-RAN White Paper, version 2.5, China Mobile Research Institute, 2011

Tomorrow's Cloud Radio Access Network (C-RAN)

A Research Collaboration Between Intel and China Mobile

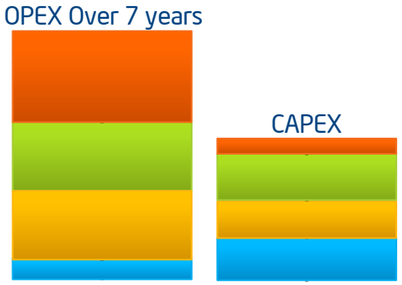
Centralized processing resource pool that can support 10~1000 cell towers with software defined radio — ***Centralized***

Multi-cell joint scheduling and processing — ***Collaboration***

Consolidate processing on standard server hardware
Multi-standard and easy migration — ***Cloud***

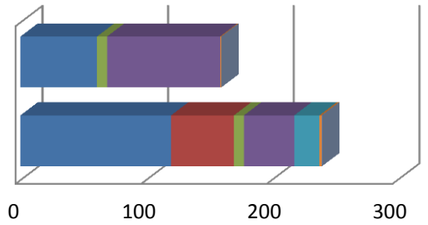
Less power consuming
Lower OPEX
Faster system roll-out — ***Clean***

Benefits of
C-RAN vs Traditional RAN



Lower CAPEX and OPEX

Save up to 15% CAPEX and 50% OPEX compared to distributed BTS 3G network*



Faster System Roll Out

Due to simpler remote radio site, system roll out can save up to 1/3 the time*

Lower Energy Consumption

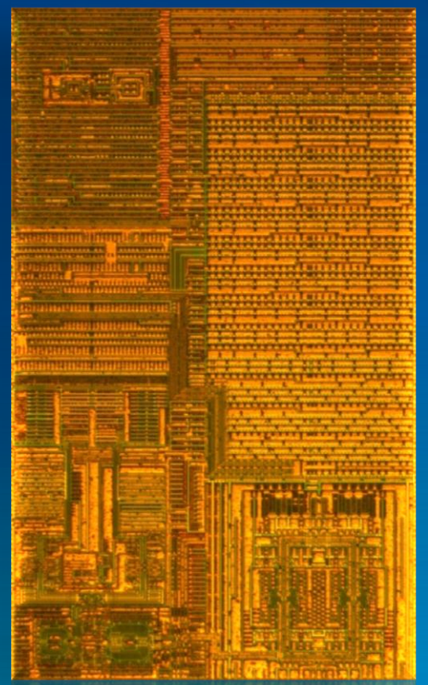
Save up to 71% of power compared to traditional RAN system*

Source: C-RAN: the Road Towards Green Radio Access Network, Bill Huang, Joint NGMN-GSMA Conference, Mobile World Conference 2012

Connecting the Future with

RESEARCH THAT MATTERS

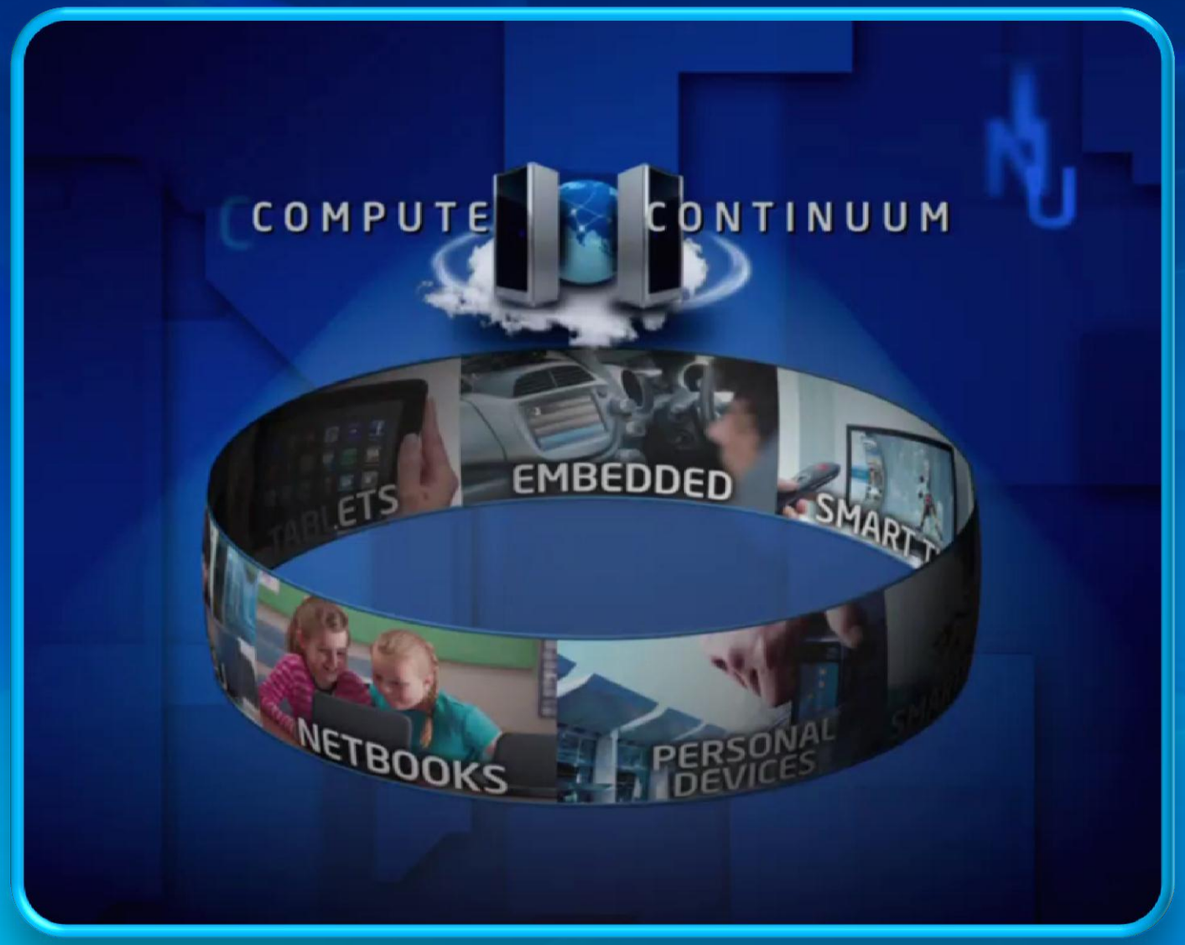
Bringing the Benefits of Moore's Law to Radio



Improving System Efficiency of Wireless

Simplifying Broadband Wireless Infrastructure

Intel: All About Using Moore's Law to Deliver Outstanding Experiences Across the Continuum



DAY1
Reinventing Computing: From Datacenter to Devices
Dadi Perlmutter

DAY 2
Security and Services in an Age of Transparent Computing
Renée James

DAY 3
Connecting the Future: It's a Wireless World
Justin Rattner


IDF2012
INTEL DEVELOPER FORUM