Analog Processing and Analytics: the "Outer Edge"

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ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

Analog Processing and Analytics: the "Outer Edge"

Agenda:

The "Lost Art" of Analog Signal Processing

- *Dinosaurs, Lizards, and Cockroaches . . .*

How Green gets more Analytic: the Importance of EDGE systems

- *Illustrative Examples*

How Analytics get more Green:

- *Smart System Partitioning*
- *Technology Advances*

Analog (in a Digital World . . .)

Dinosaurs, or cockroaches ?

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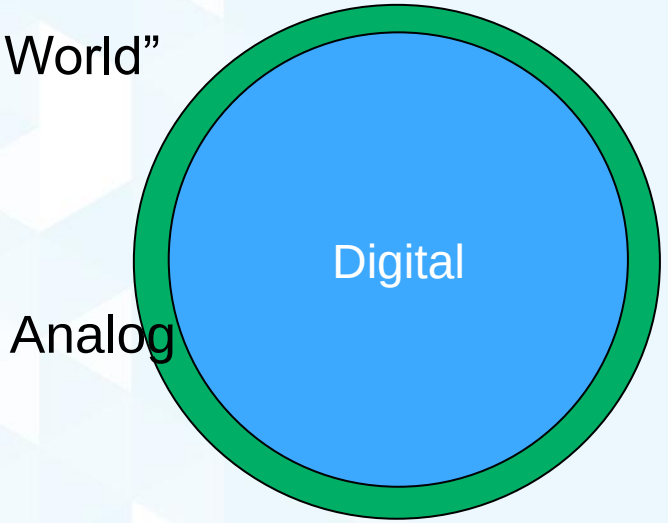
Semiconductors from an Analog Perspective

Analog Circuits: Past and Future?

Signal Processing World as an “Expanding Sphere”



- Volume Increases as R^3
- Surface Area Increases as R^2
- Key Question: How “Thick” is the “Crust” (Outer Edge) ?

The existing paradigm of “Digitize it all and send it to the datacenter” Is not practical

(What the SRC Decadal Plan refers to as the “Data Deluge”)

The EDGE is Critical to Green . . .

The edge is where data is born . . .

And where the action is . . .

Wildfire Detection

Rangers in towers with binoculars
Satellite Imaging
Distributed/networked ground sensors

“Networked Ocean”: Woods Hole Initiative

Challenge:

Generate better insights with continuous monitoring across a wide range of biological, chemical and other “ocean vital signs”

Extend observation capabilities across large areas and to full ocean depth

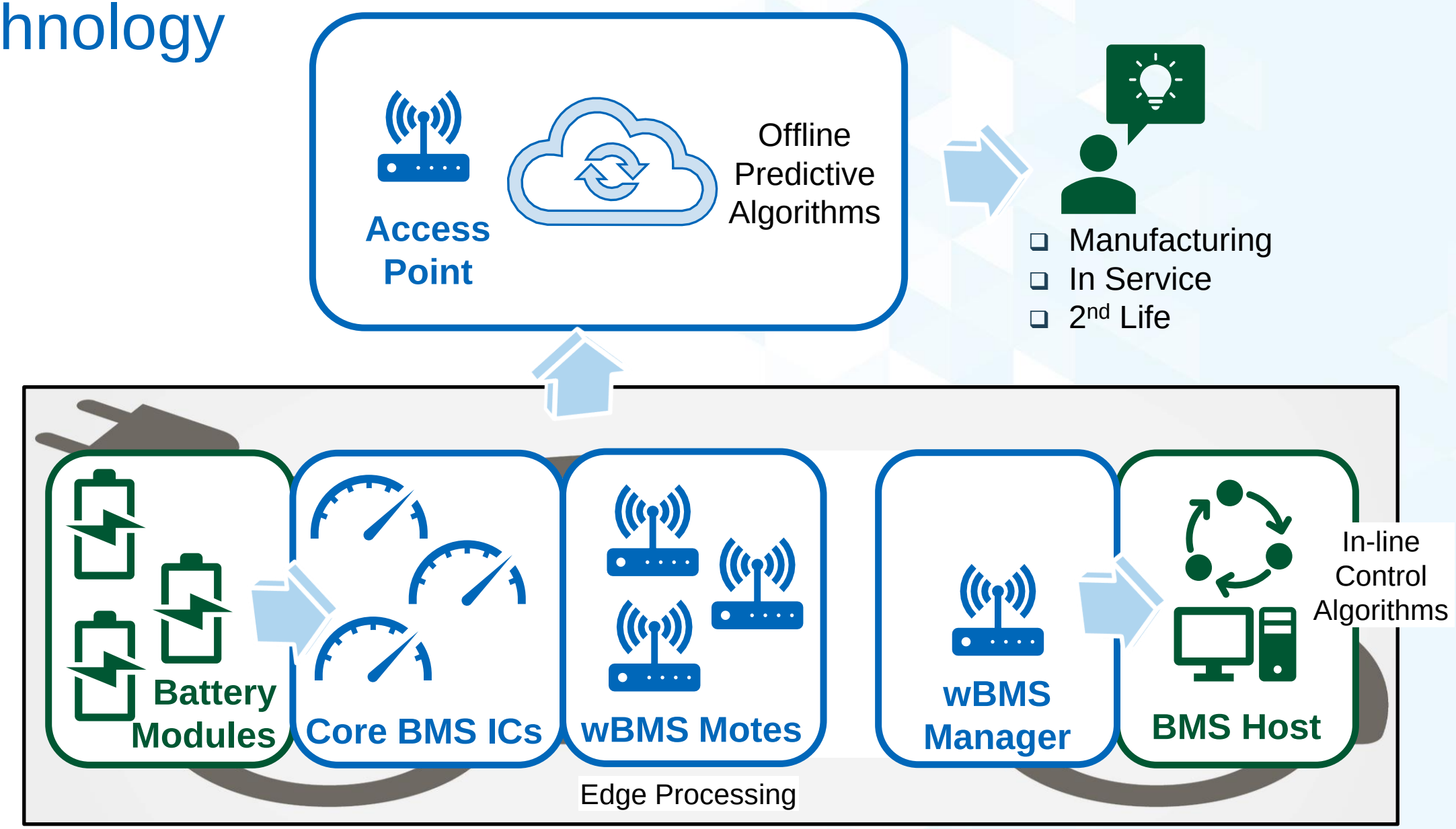
Challenge:

Create an “always on, always connected” ocean, analogous to networks for weather monitoring and forecasting

Challenge:

Leverage and scale research insights and analytics in the ultimate “internet of things” challenge of interpreting data from globally distributed sensors and a “networked” ocean

EV Battery Management System (BMS) Technology



Partitioning and Innovation: Making Analytics “Greener”

Processing “Chain”

(note– depending on situation requiring action, this may be a “round trip” journey back to an actuator . . .)

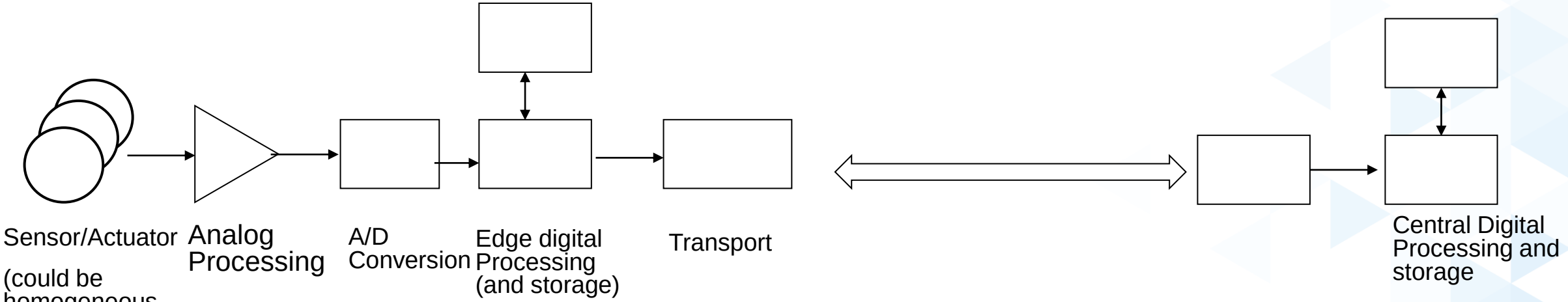


FIGURE OF MERIT: VALUE / COST

Value: Data → Information → INSIGHT (modifiers: location, confidence: accuracy, security: trust)

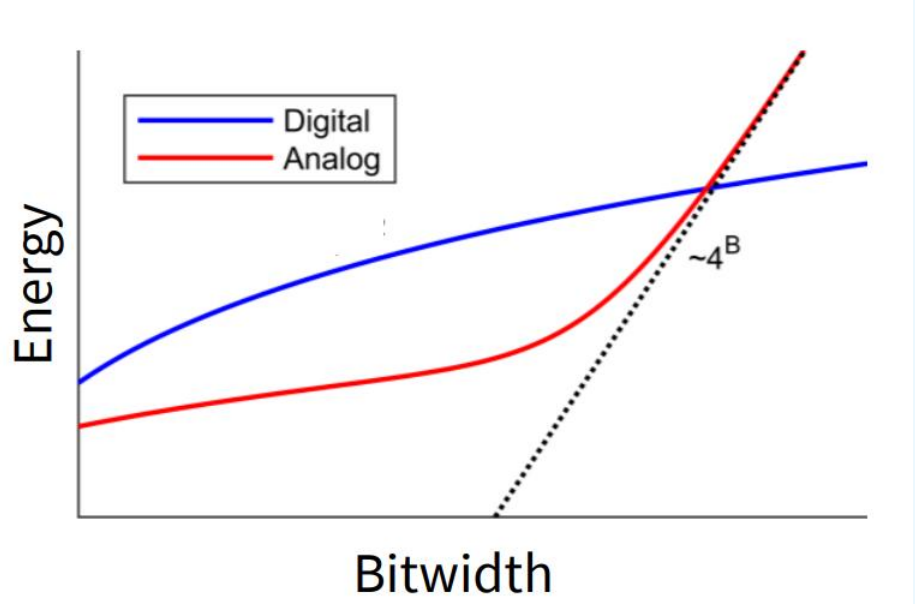
Cost: Power (as a convenient proxy)

Concept of “Smart Partitioning”

Value and Cost: Technology Dependence

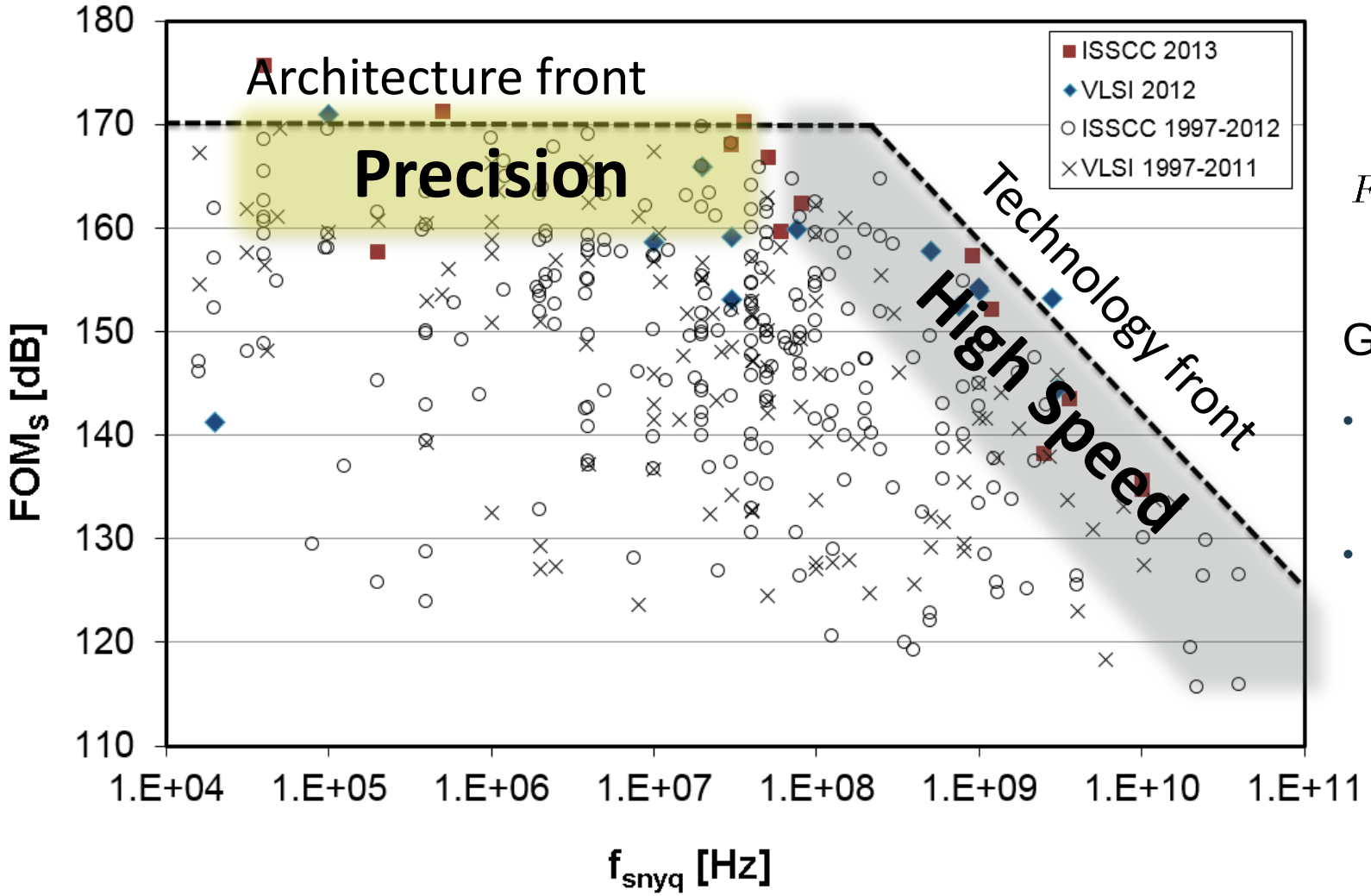
- There are some “physical limits”, but practical implementations are frequently still far away from those
- Slopes can be guides: Example: cutting noise in half often requires 4X more power ***
- “Crossover” points can shift with technology (digital often wins this race)
- Confidence: often improved through redundancy: can be homogenous or heterogenous (eg sensor fusion)
- Don’t forget location (and related issues of latency)
- Security as an emerging issue
  - “Data is the new oil” or “Hoarders” ?
- Optimization vs. Flexibility (cost of change)

Also note significant APPLICATION dependence



M. Verhelst and A. Bahai, "Where Analog Meets Digital: Analog?to?Information Conversion and Beyond," in *IEEE Solid-State Circuits Magazine*, vol. 7, no. 3, pp. 67-80, Summer 2015, doi: 10.1109/MSSC.2015.2442394

ADC Example: Schreier's FOM plot



$$FOM_3 = SNDR_{dB} + 10 \cdot log\left(\frac{BW}{P}\right)$$

General Observations:

- Frontier advances with time (process and circuit innovation)
- There is a point where additional speed costs efficiency

[B. Murmann, ADC Performance Survey 1997-2013]

ANALOG DEVICES
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CLOUD

Big Data Processing
Business Logic
Data Warehousing

EDGE

Edge Devices
Realtime Data Processing
At source/on premises
Data Visualization
Basic Analytics
Data Caching, Buffering
+ more...

MORE...

SENSORS AND CONTROLLERS

Vital Signs

Video Capture

Location Detection

Battery Monitoring

Rotation

Axis Detection

pH

Humidity

Temperature

Pressure

More...

INDUSTRIAL AUTOMATION

HEALTHCARE

AUTOMOTIVE

CONSUMER

COMMUNICATIONS

AEROSPACE & DEFENCE

INSTRUMENTATION & MEASUREMENT

Summary Thoughts

- **Remember the cockroach: Analog is not extinct→ it's due for a "comeback"**
- **The "Data Deluge"/"Hoarders" problem: our goal is insight, not just "more data"**
- **This includes the "green" applications**
- **Moving from "Information theory" to "Insight theory" is highly application dependent: one person's noise is another person's signal**
- **There is a lot of interesting stuff going on at "the outer edge"**

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