

The World Leader in High Performance Signal Processing Solutions



Layers of Innovation: How Signal Chain Innovations are Creating Analog Opportunities in a Digital World

Dave Robertson-- VP of Analog Technology





Moore's Law and Technology Progression

The OVERSIMPLIFIED Story:

A steady advance in lithography that drives exponentially greater density, lower cost, lower power, higher speeds, and higher levels of integration.



Moore's Law and Technology Progression

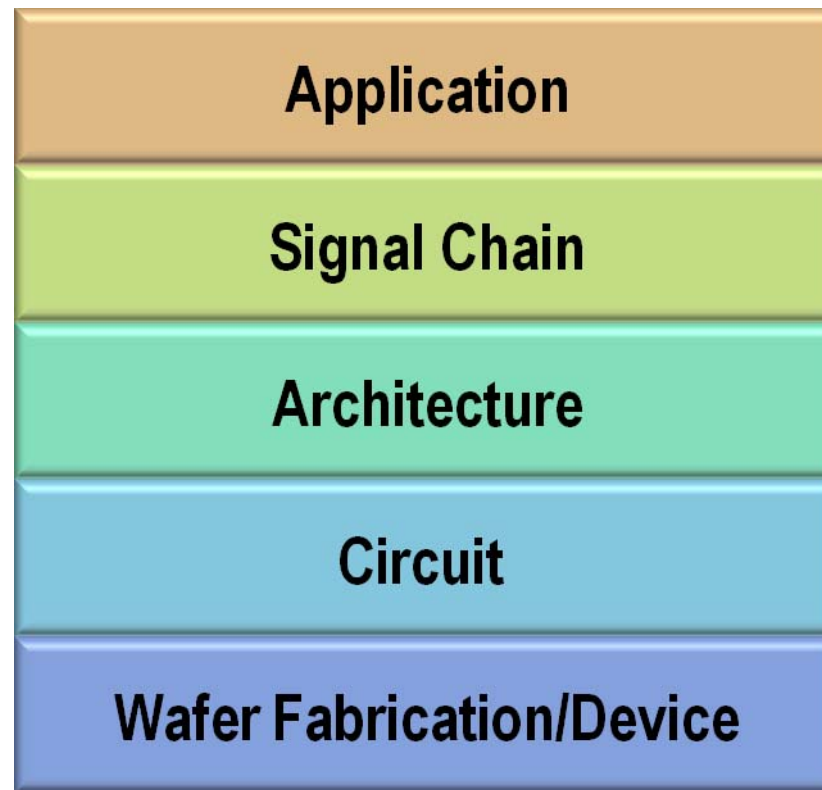
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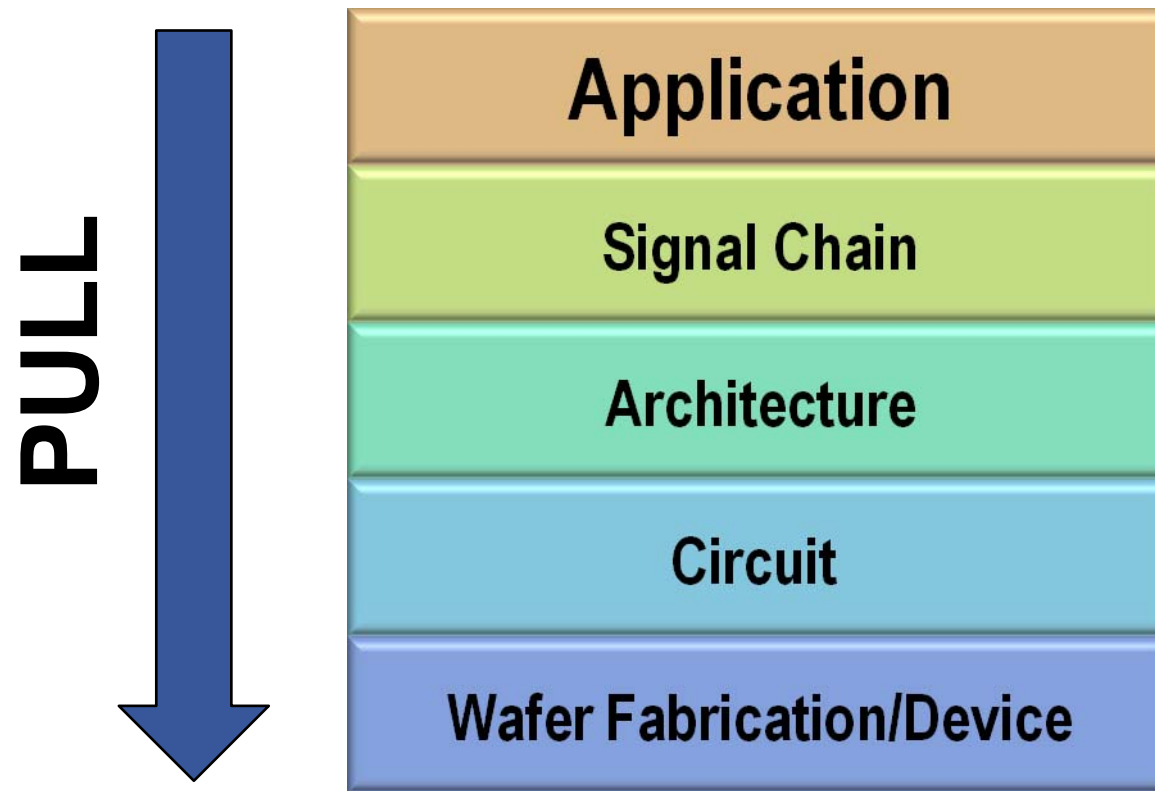
The REAL Story:

Evolutionary and Revolutionary innovation across many dimensions that has pushed, pulled, and bounced our industry forward.

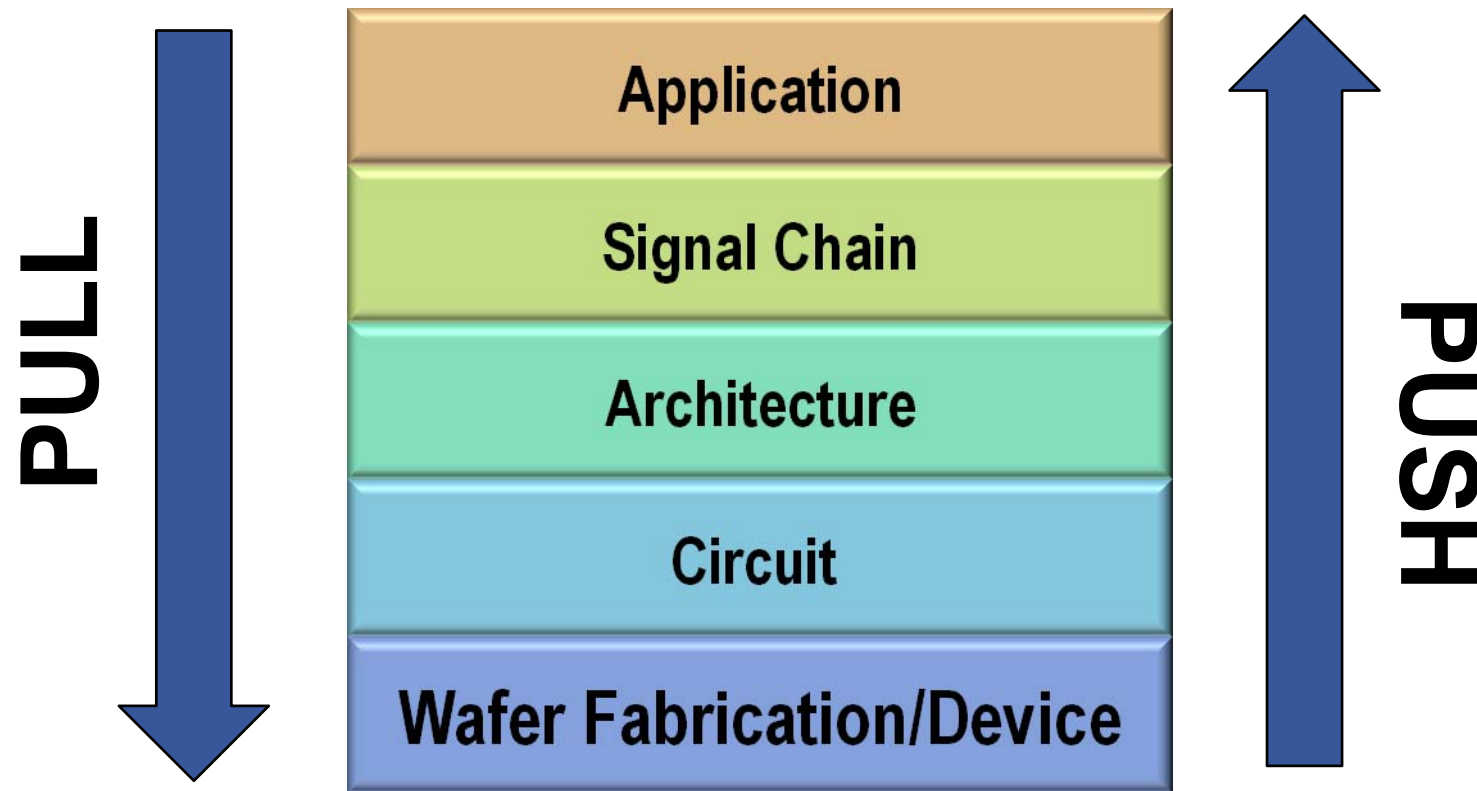
Layers of Innovation in the Semiconductor Industry



Application/Necessity Driven Innovation



Technology/Capability Driven Innovation



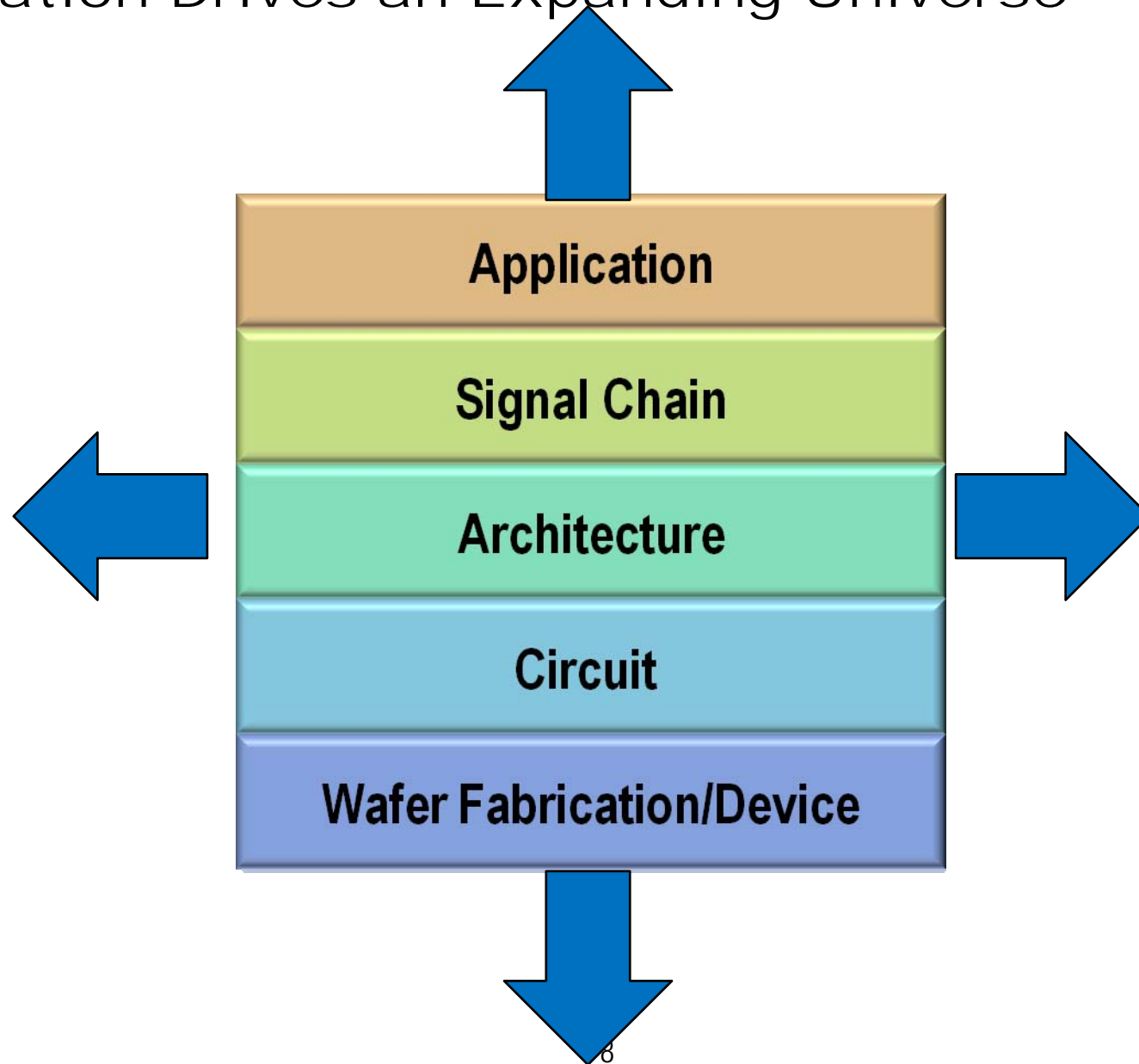
The Evolution of Signal Processing Functions

- ◆ Unobserved → Sensed/Observed → Measured → Analyzed → Controlled

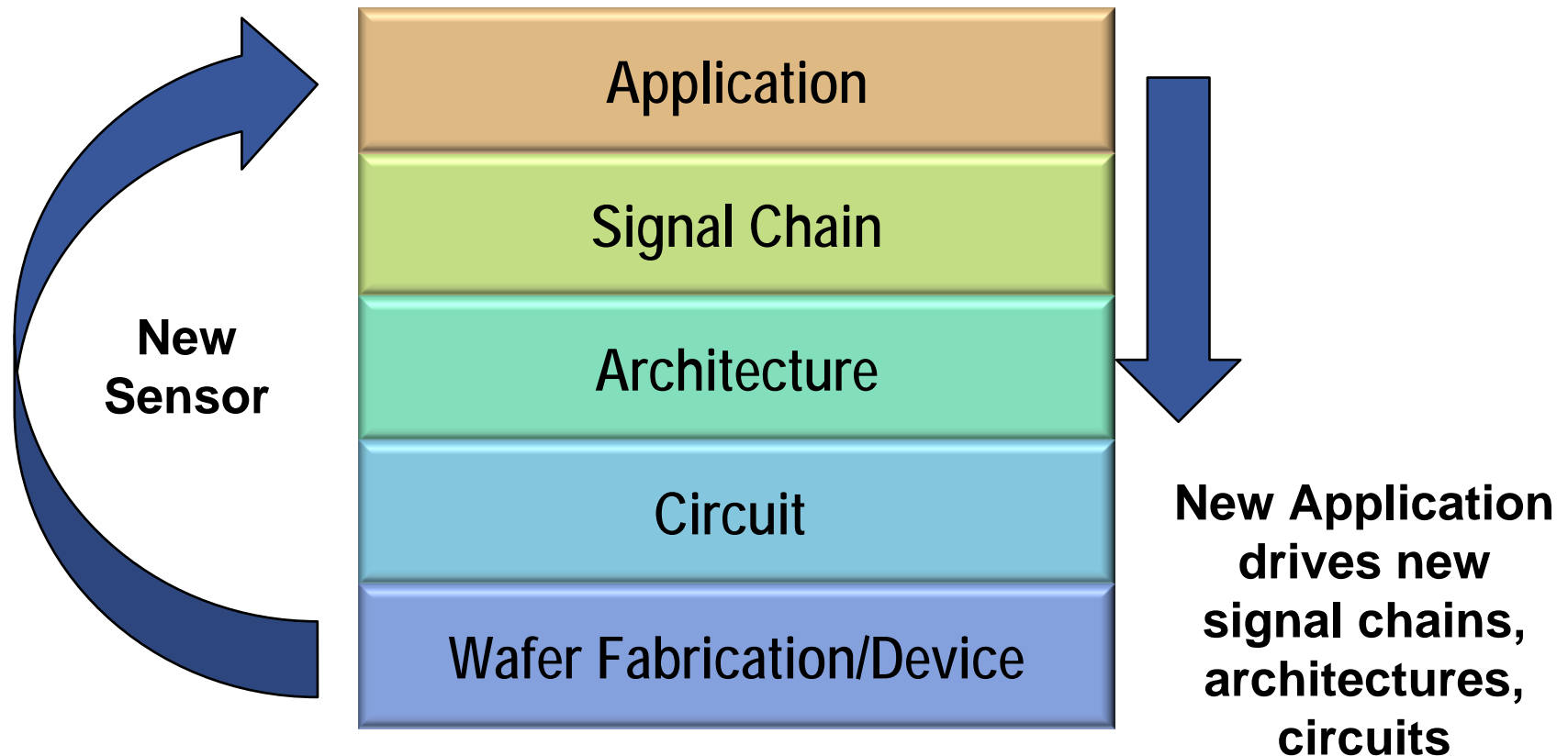


- ◆ Mechanical → Electrical (analog) → Electronic (solid state analog) → Electronic (fixed function digital) → Software

Innovation Drives an Expanding Universe



New Sensor/Actuator Technologies Drive Entirely New Signal Chains



Examples: Accelerometers, Gyros, Gas Sensors, Optics



A Shift in Signal Processing Emphasis?

The First 150 years:

The primary challenge is to extract the signal from the background noise.

The New Era:

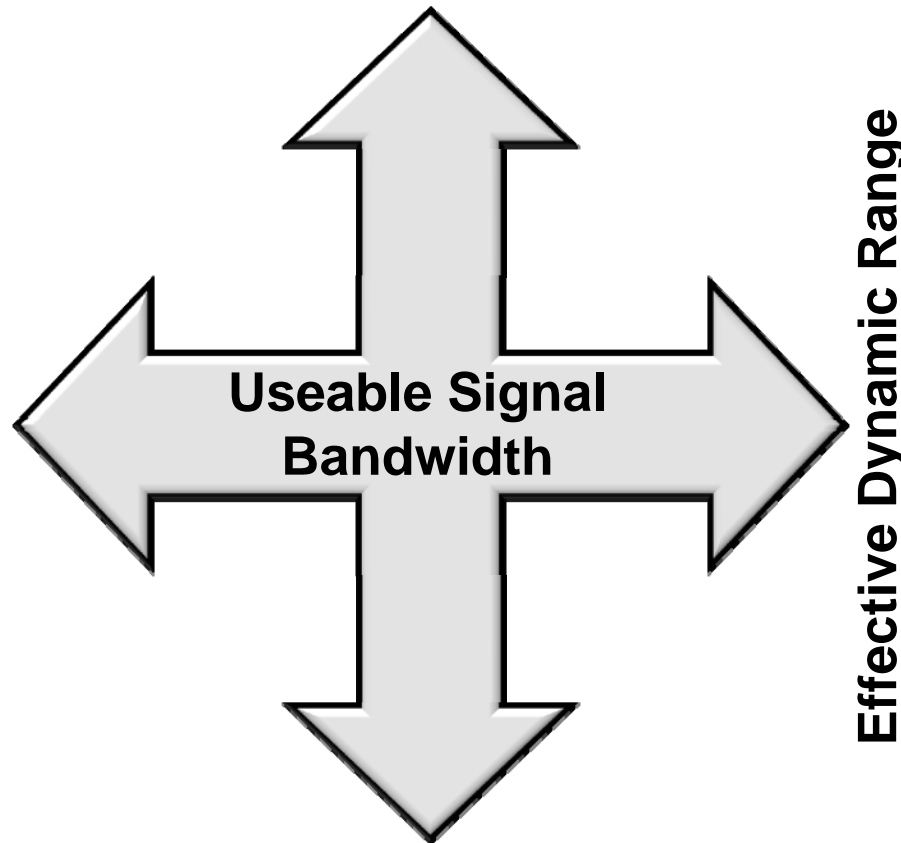
Increasingly, the challenge is to extract the signal from dense traffic of other signals, or interferers.

Advances In Signal Processing: Enlarging "Shannon's Box"



Largest "Captureable" Signal

"The Ceiling"



**Useable Signal
Bandwidth**

Effective Dynamic Range

"The Walls"

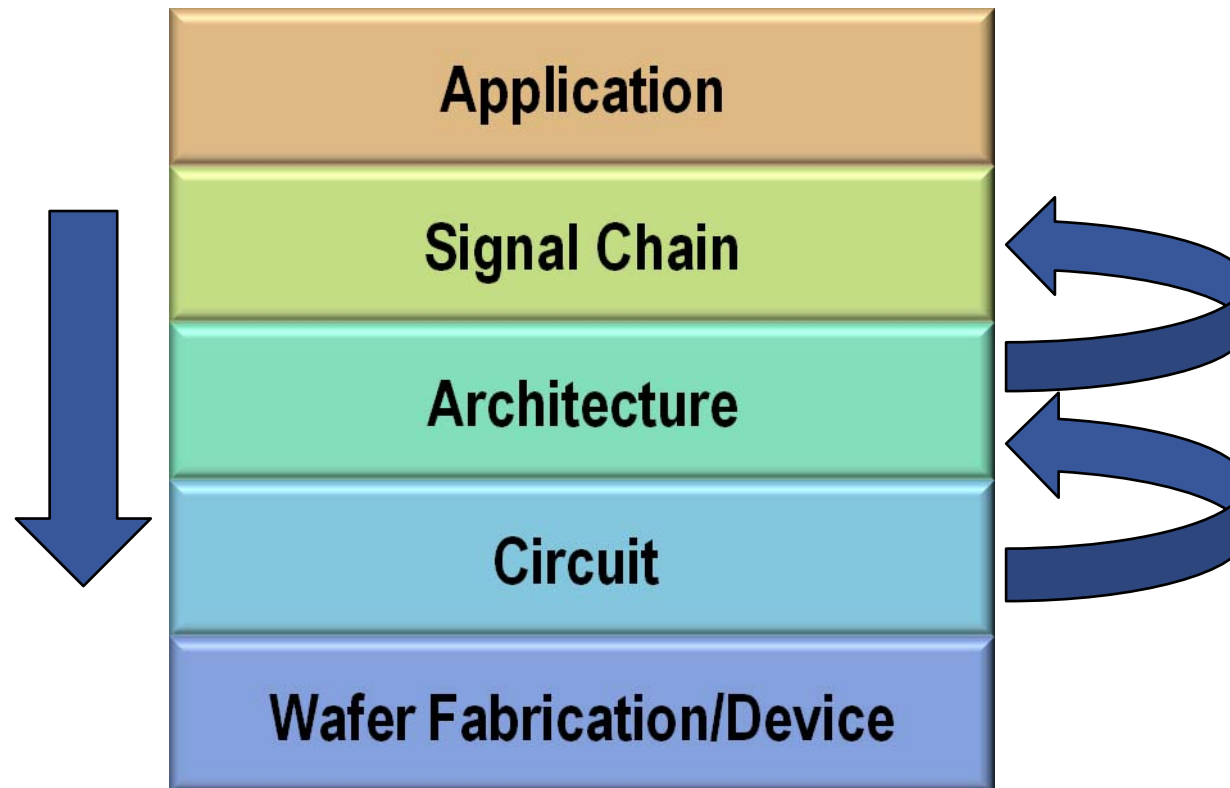


Smallest Detectable Signal

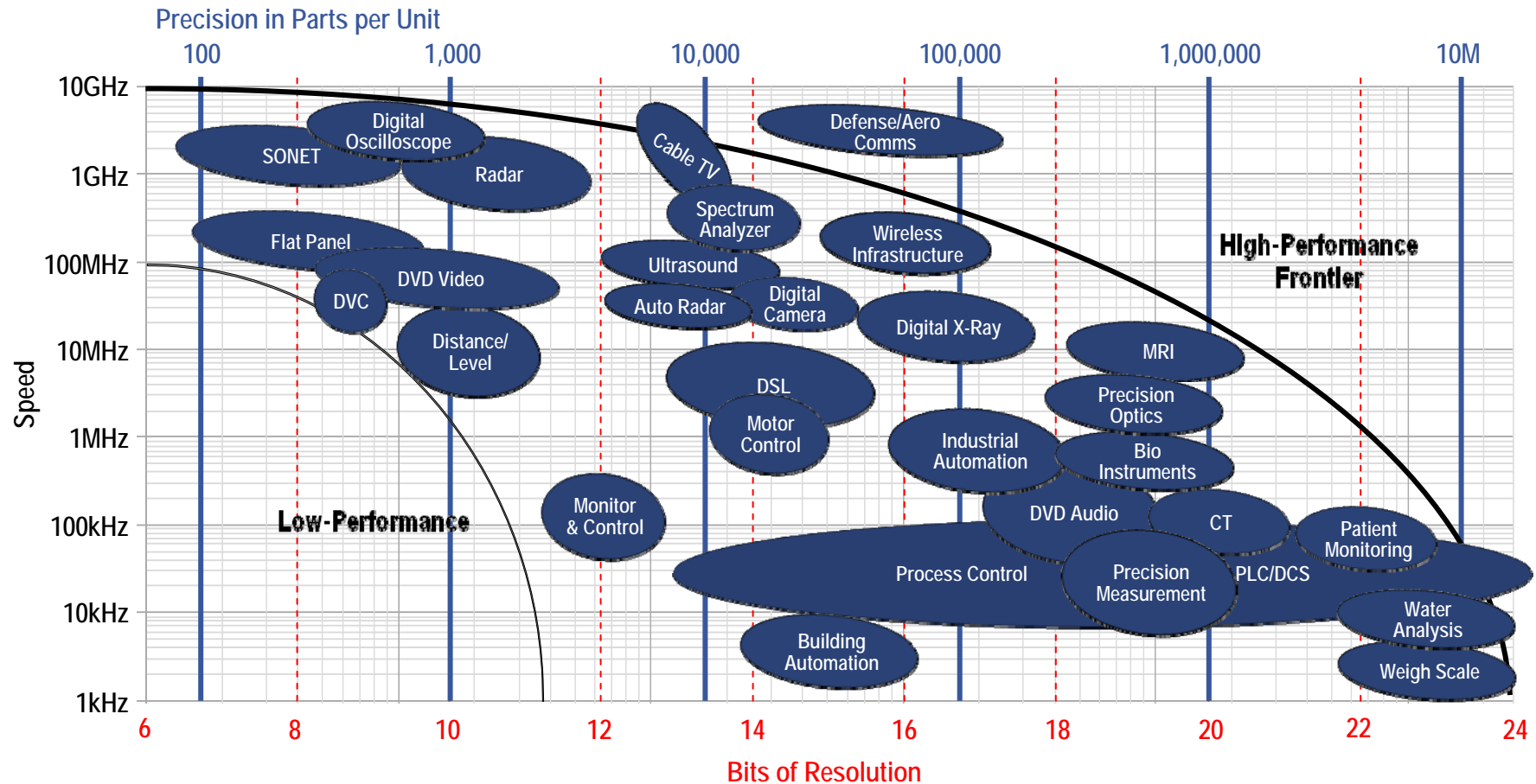
"The Floor"

Signal Chain
Requirements call for
Higher Performance

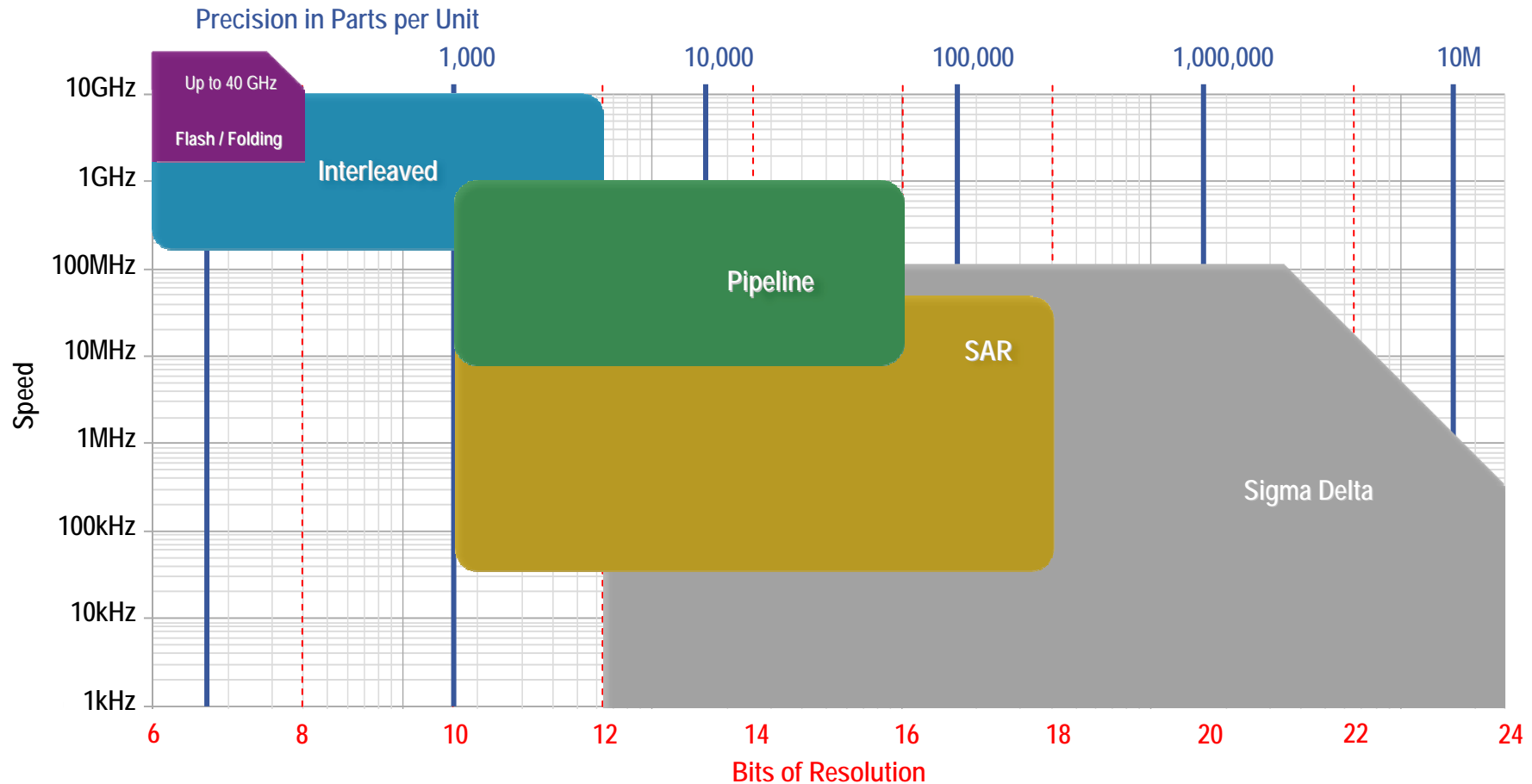
Innovations in Circuits
and Architecture enable
entirely new Signal
Chains



Application Requirements for Dynamic Range and Bandwidth



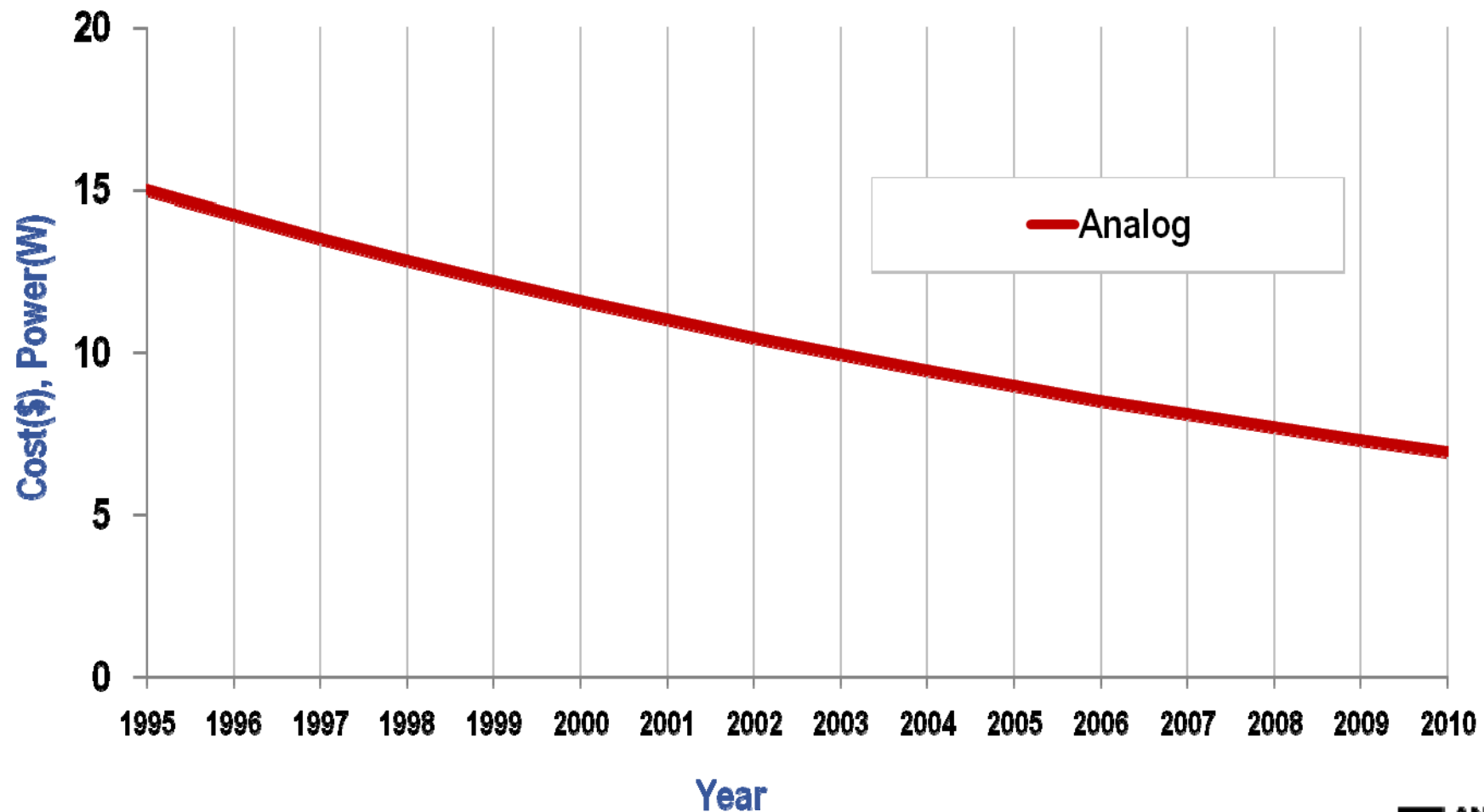
Architectures: Dynamic Range and Bandwidth (Data Converter Example)





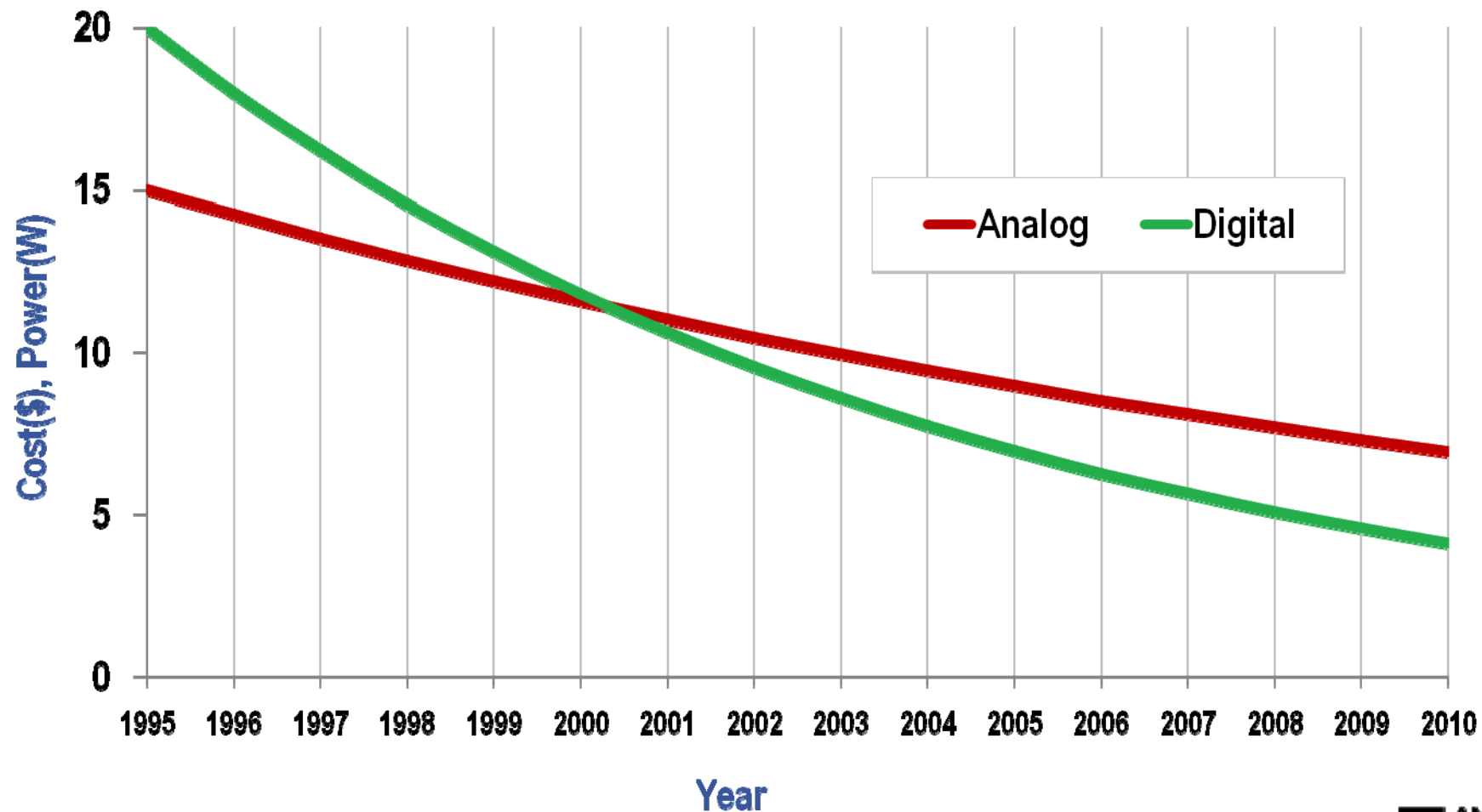
Reflecting on Some Trends . . .

Analog gets cheaper over time...



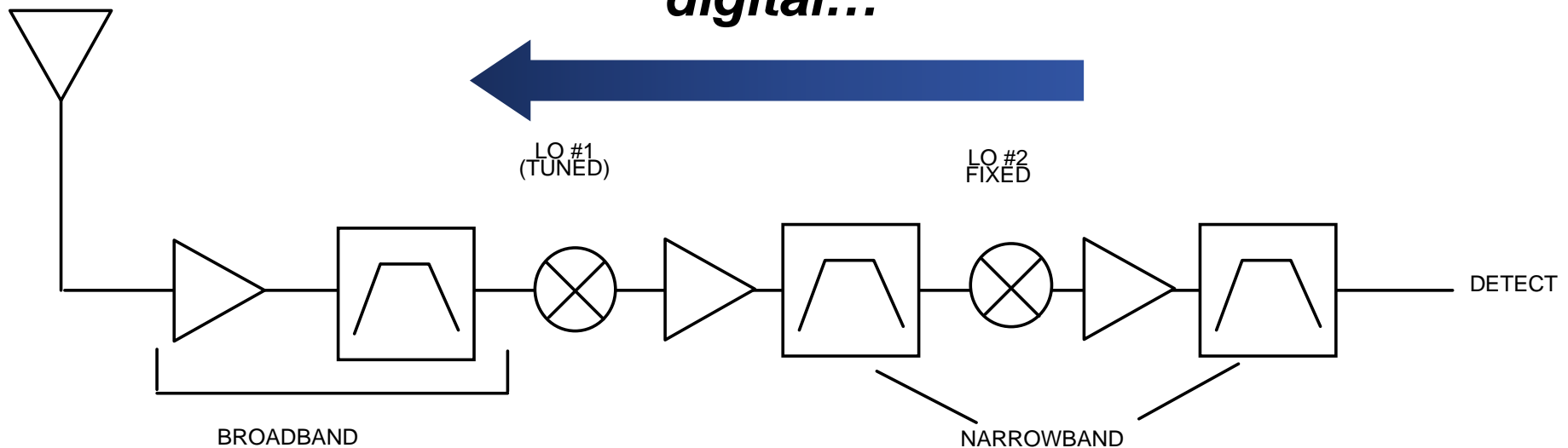
Analog gets cheaper over time...

...but digital gets cheaper faster!



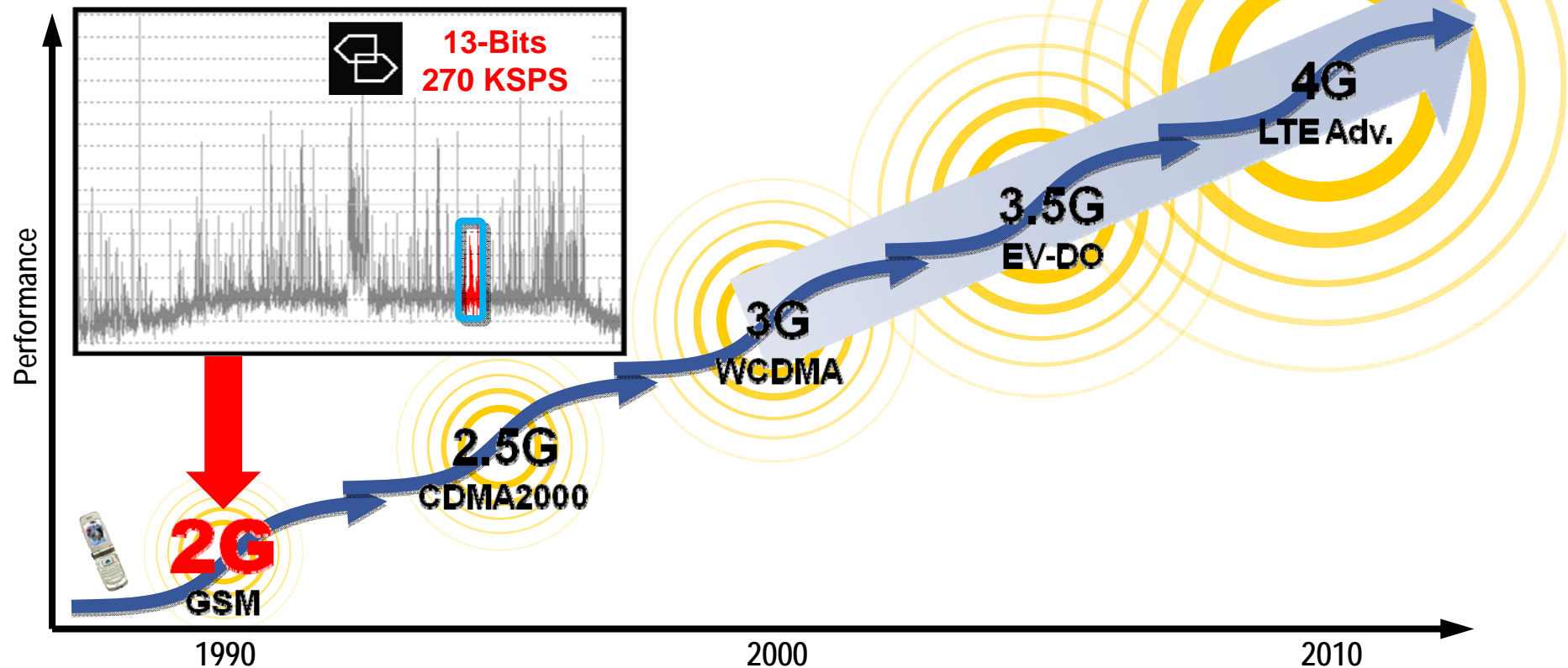
Signal Chain Trend: Move Converter Closer to “the Source”

***As converter moves towards the antenna,
analog signal processing is replaced by
digital...***

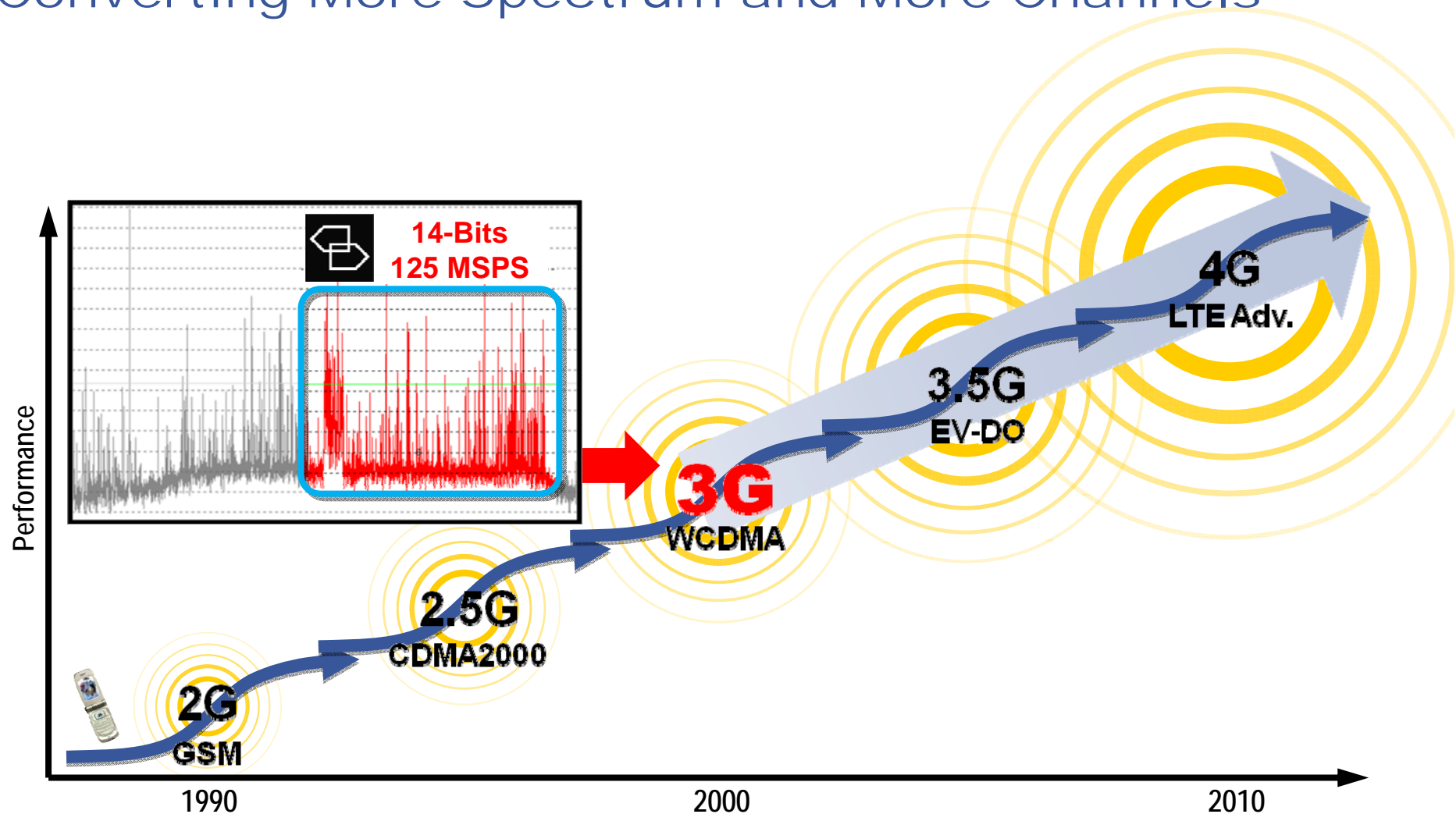


***But the remaining analog/mixed signal
processing gets significantly more challenging***

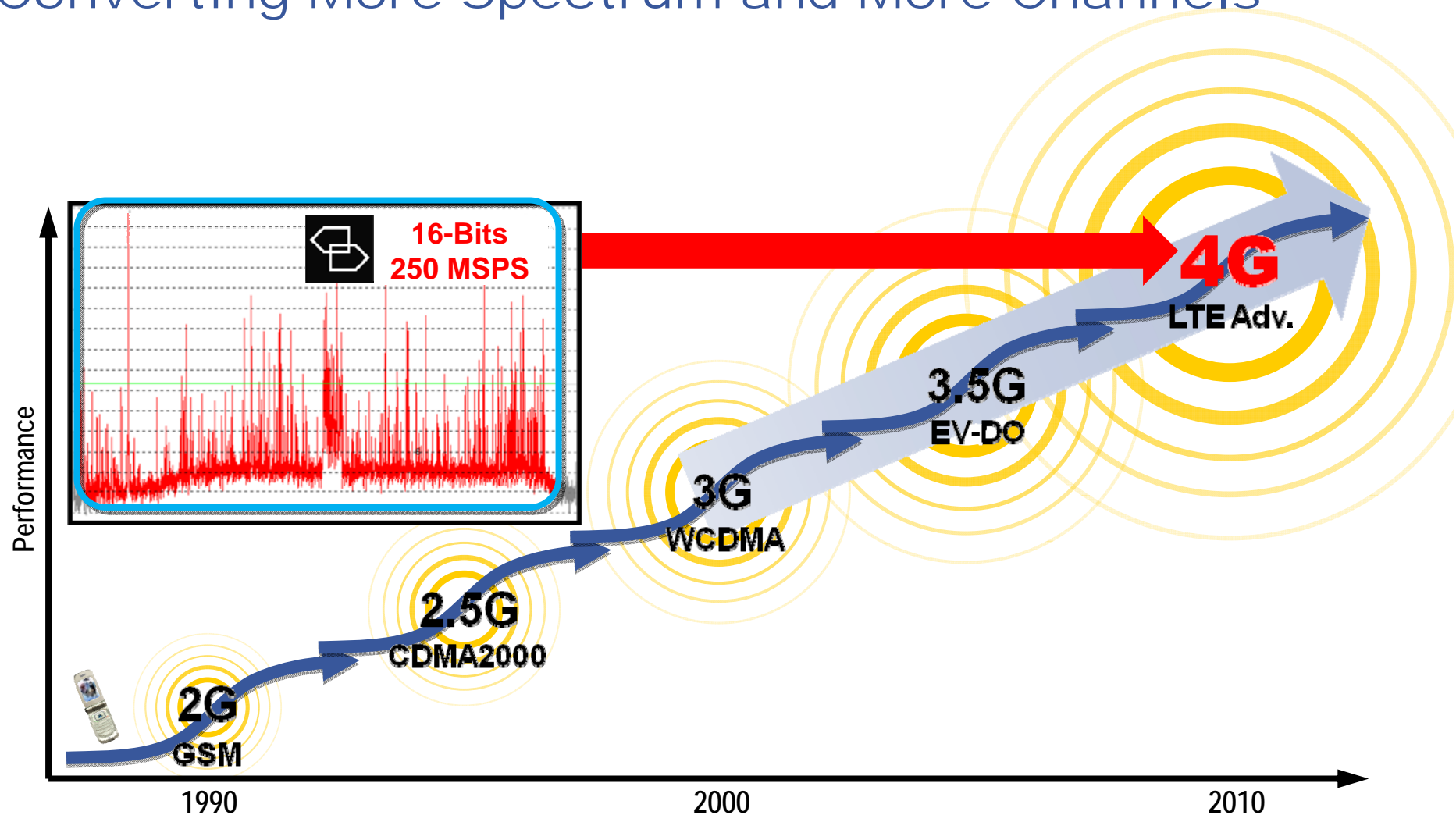
Wireless Infrastructure Example: Converting More Spectrum and More Channels



Converting More Spectrum and More Channels



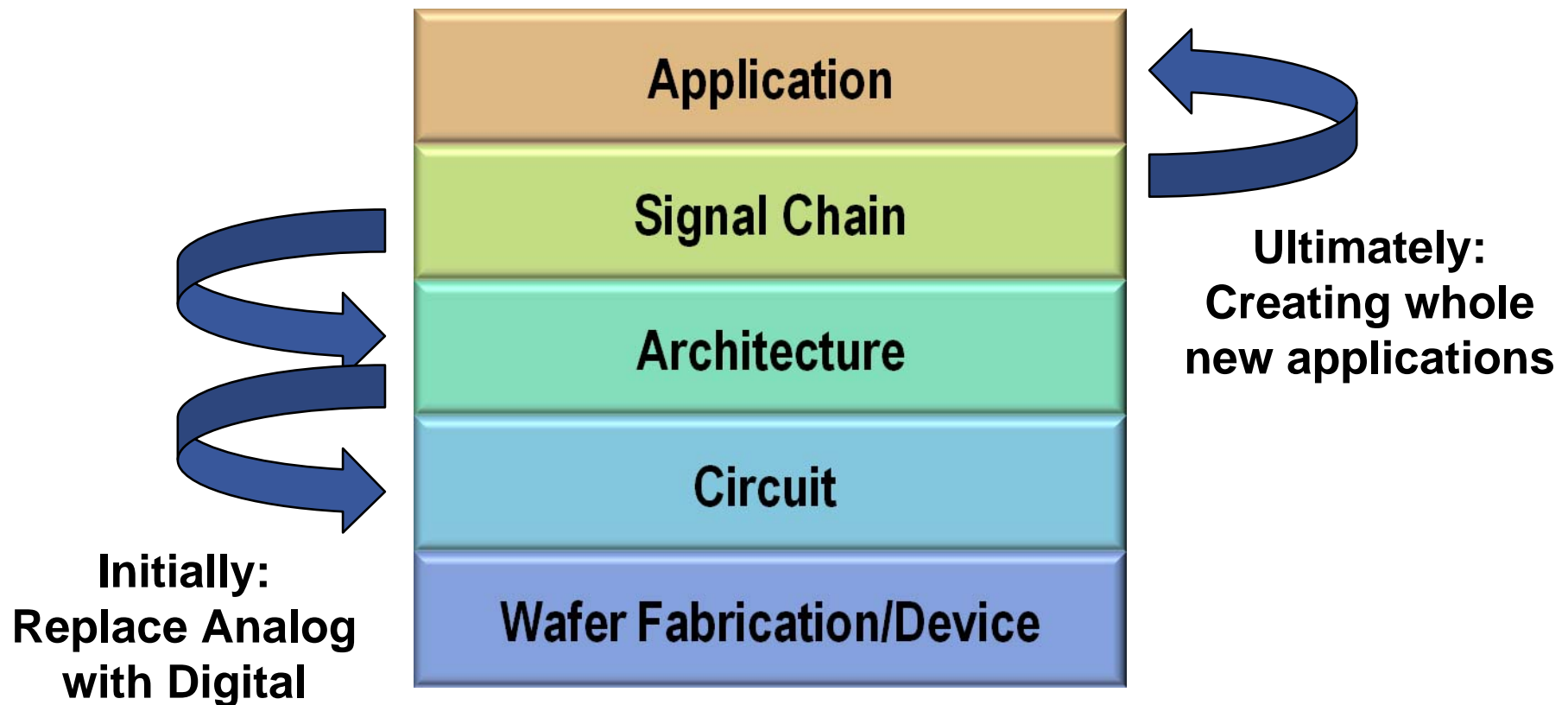
Converting More Spectrum and More Channels



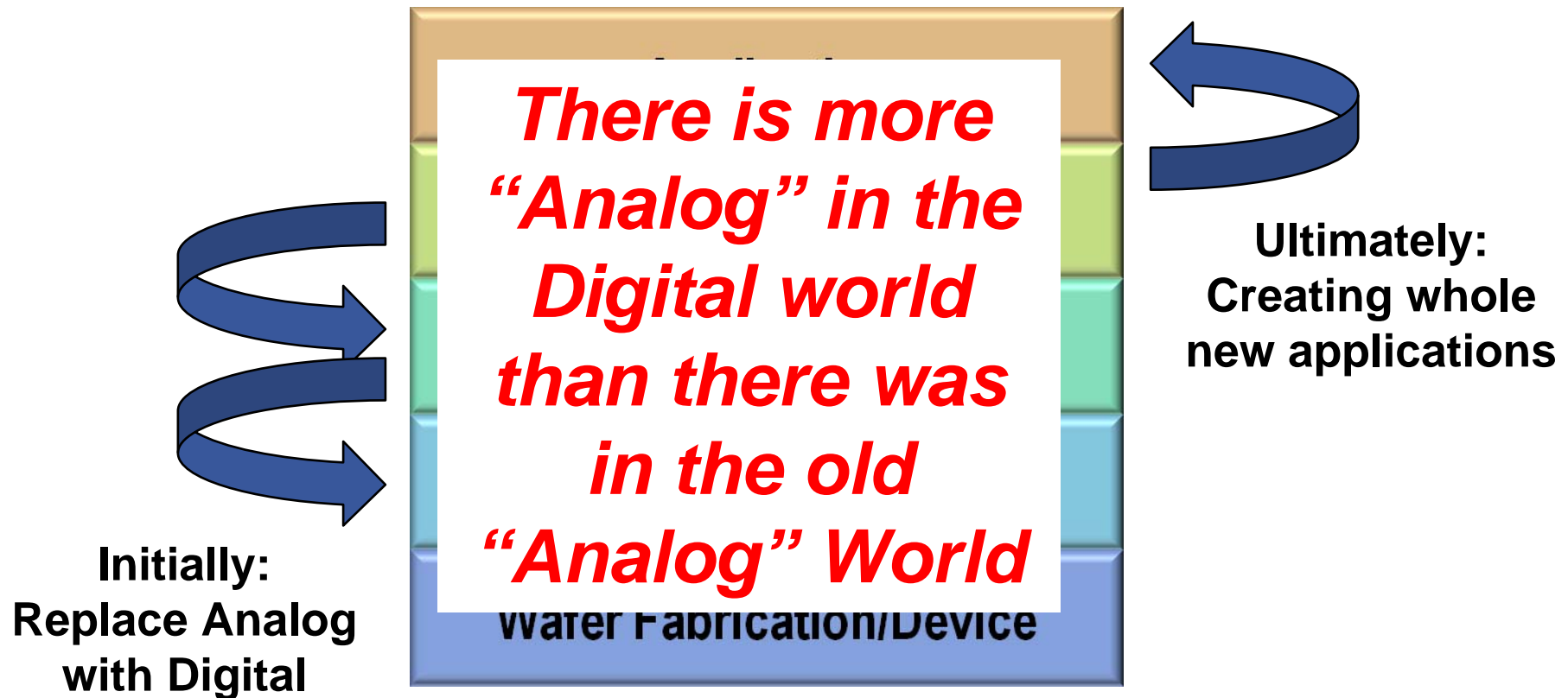
Audio Recording, Mastering, Playback, Distribution, Sales – from Analog to Digital



"Going Digital" – Replacement Technology drives Entirely New Applications/Business Models



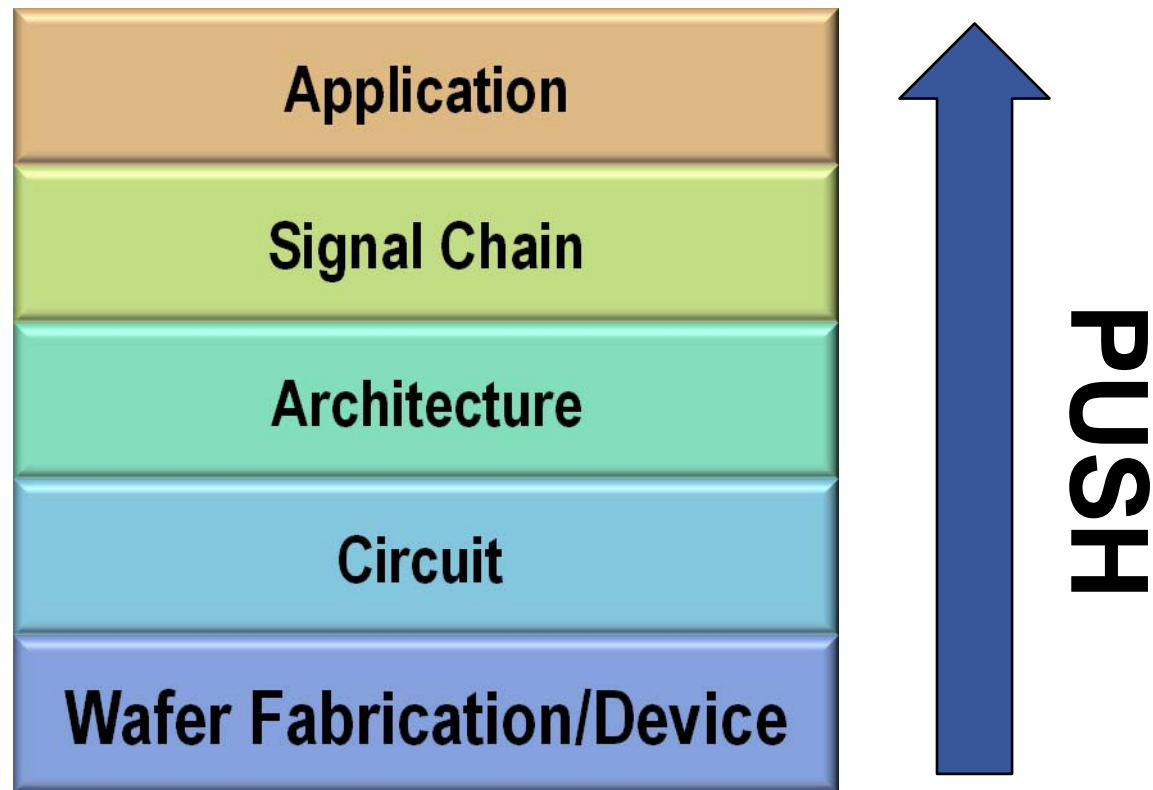
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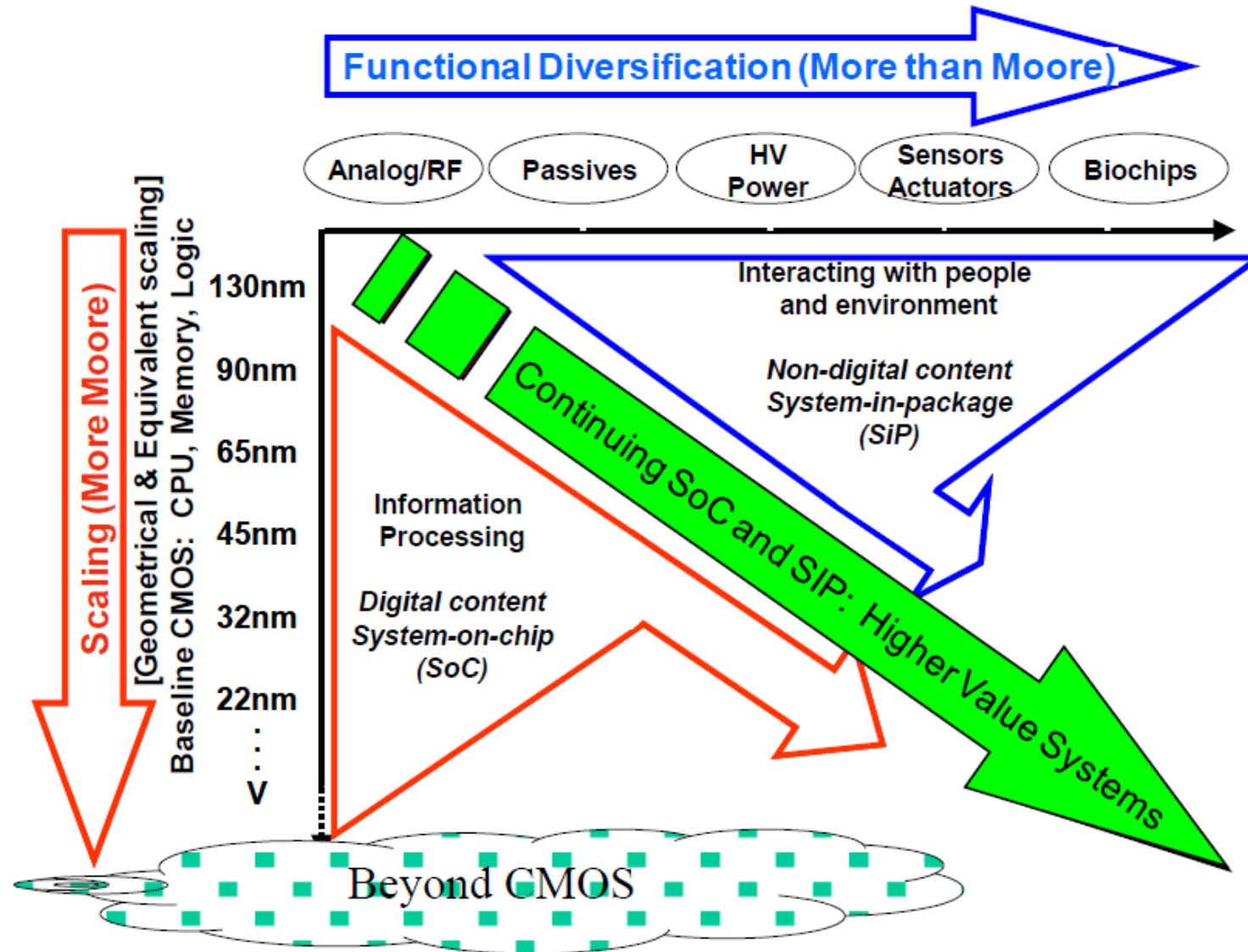


Moore's Law . . .

Process Innovation as a Driving Force



ITRS Roadmap Overview





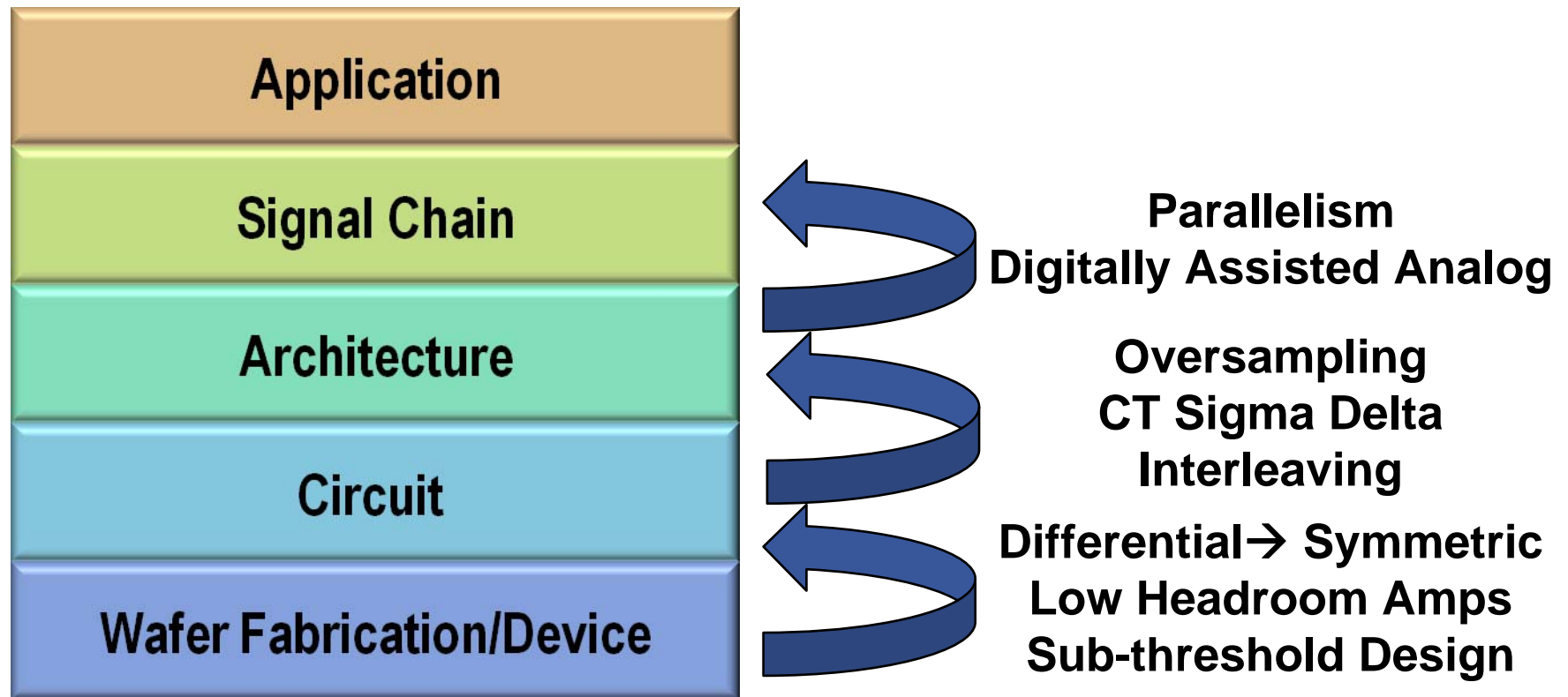
Deep Submicron Challenges for Analog (Moore's Law is Not Universal . . .)

- ◆ **Reduced Supply Voltages (and signal swings)***
- ◆ **Reduced Gain of the transistors ****
- ◆ **Leakage Currents in “OFF” devices**
- ◆ **Gate Leakage currents**
- ◆ **Increased 1/f noise**

In most cases, the analog circuits do not scale as aggressively as digital: cost per function may actually go up.

In SNR limited circuits, Capacitance must scale with signal voltage SQUARED, so reduced signal swings may actually lead to an INCREASE in power consumption.

The “Constraints” of Deep Submicron Technology Drive Innovation at the Circuit, Architecture and Signal Chain Levels . . .





Integration . . .



Benefits of Integration

REWARD

Smaller Size

Save Package Pins (money)

Save Interface Overhead: Area

Save Interface Overhead: Power

Save Interface Overhead: Speed

Allows System Optimization

Has become one of the most compelling (perhaps irresistible?) forces in our industry . . .



But These Benefits May Come at a Price . . .

REWARD	Penalty
Smaller Size	Can no longer independently optimize process selection
Save Package Pins (money)	Greater potential for interference between blocks
Save Interface Overhead: Area	Increases IC complexity: power supplies
Save Interface Overhead: Power	Increases IC complexity: schedule
Save Interface Overhead: Speed	Increases IC complexity: risk
Allows System Optimization	Increase Verification/Test Complexity
	May encounter power density issues

A thoughtful approach is necessary– certain functions may be cheaper/better when not integrated: DRAM, POWER AMP . . .



Key Issues for “Optimum Integration”

◆ Process Technology:

- which functions can be realized on which technology

◆ Interfaces:

- analog vs. digital, CMOS vs. LVDS vs. SERDES (bandwidth and dynamic range)

◆ Package and Board Technology: SoC vs SIP

◆ Power:

- Supply voltages
- Power Dissipation

◆ Risk: Time to Market

◆ Market Dynamics:

- Market size and Life Cycle



Summary

- ◆ **There are MANY “Driving Forces” of Innovation in the Semiconductor Industry**
- ◆ **Innovation in the Different Levels, or “Layers” is Often Interconnected: a “Dance” of Push and Pull Forces**
- ◆ **As Signal Chains “Go Digital”, the Mixed Signal Functions Become More Challenging**
- ◆ **Moore’s Law and Integration Remain Very Important Drivers in Our Industry, But SOC Integration is Not the Right Answer to All Problems**