adaptive

QUICKSILVER technology™

# From the Wireless Zoo to Eden

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computing

# What’s a Zoo?

- Place we visit infrequently
- See wild and exotic creatures
- Looks great but don’t touch
- Not the real world
- Rarely changes
- Often an expensive trip
- Don’t return for years
- Leave with souvenirs

# What's a Garden?

- Familiar, tranquil
- Variety and interest
- Do what you want
  - Work/play/visit
- When you want
- Variety of choices, any day
- Grows and evolves
  - But always familiar and comfortable
- Place we seek out and return

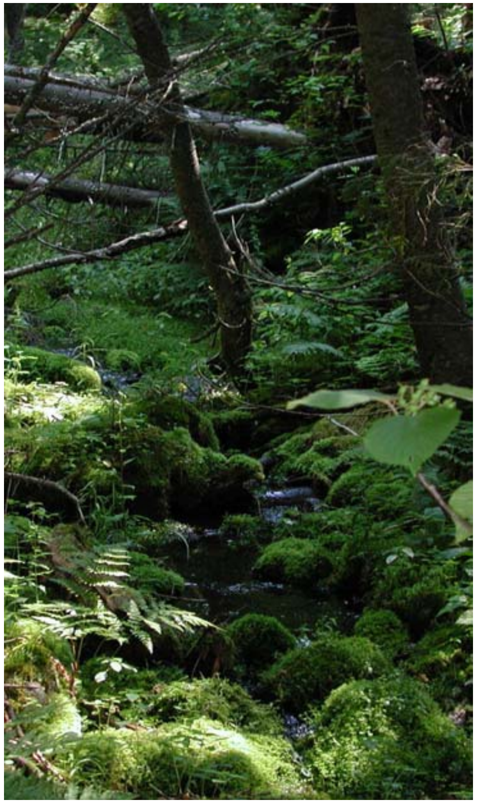
Eden

# The Wireless Zoo

- Visit intermittently
  - New apps break it; no coverage; just doesn't work
- Populated with wild and exotic technologies
  - 802.11a/b/g, WiFi, CDMA, GPRS, 3G…
  - Wonderful demos but…
- Long-lead time to deploy new services
  - Expensive yet unsatisfactory/confusing
  - High speed, low speed, really mobile?
- Carriers discourage coming back
  - Messy calling plans; confusing and complex for users

- Leave with souvenirs – obsolete phones/PDAs

# The Wireless Eden



- Consistent and ubiquitous
- Move seamlessly between any protocol and band
- Same communications device works on all networks
- Device adapts itself to the network
- Removes complexity/confusion
  - Designers -- Faster development time
  - Carriers -- New services deployed quickly, at low cost, new revenue streams
  - Consumers – A streamlined wireless/mobile computing experience

# Getting Past the Gates

- Traditional IC technologies can’t meet demands
  - All fixed-function silicon
- ICs (and devices) can’t evolve and adapt at run time
- More expensive and limited than what is required
- Too many gates/entry points
  - 802.11a/b/g, WiFi,  CDMA, GPRS, W-CDMA, 3G, 4G

# Solution: Adaptive Computing Machine

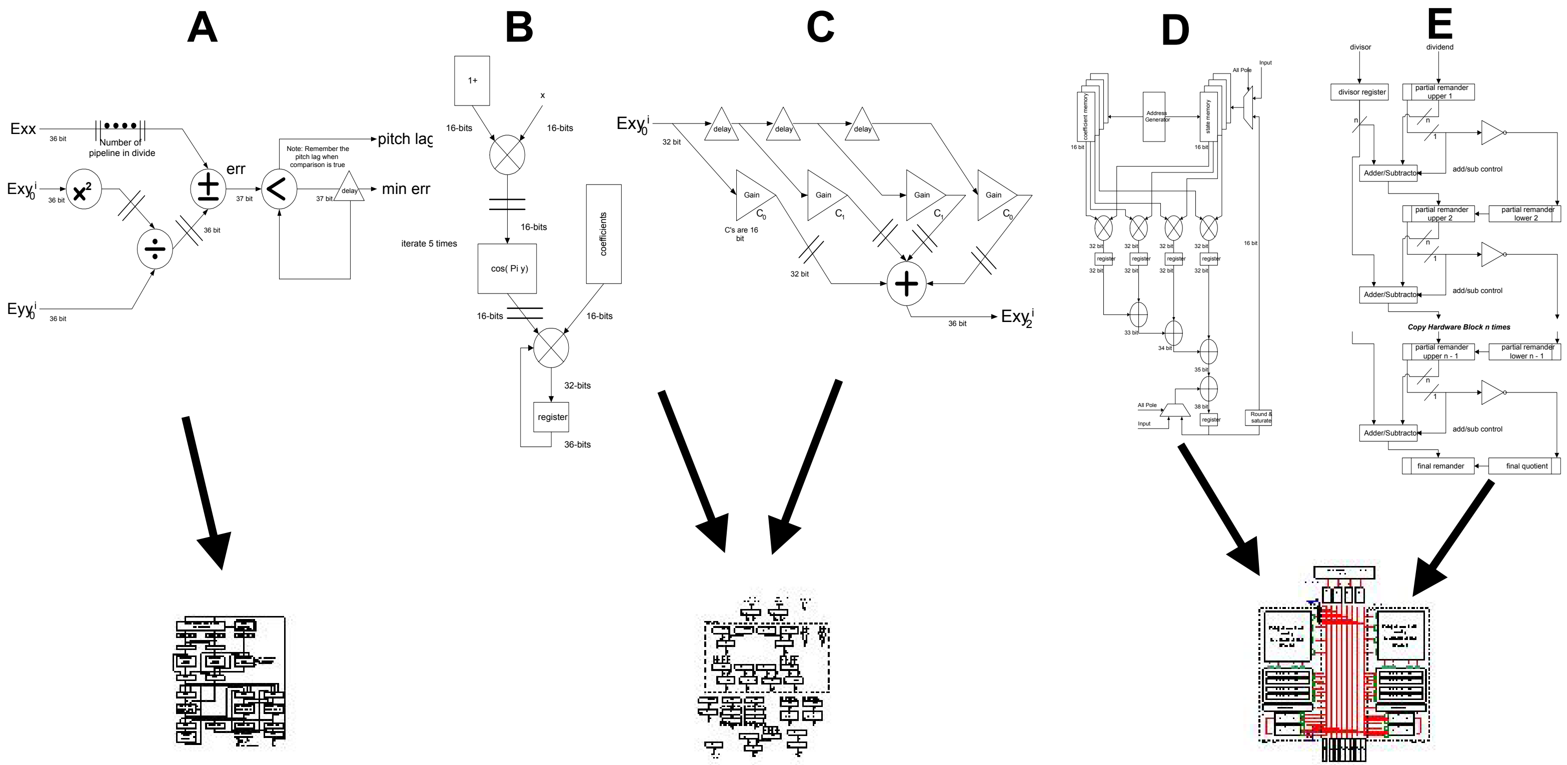
ACM adapts rapidly, on-the-fly, to perform many tasks

- Fully programmable at run time
- Creates the specific hardware needed to perform new or different functions

The ONLY, ALL software-programmable IC

# Solutions Come from Algorithms

Algorithmic elements of CDMA vocoder example

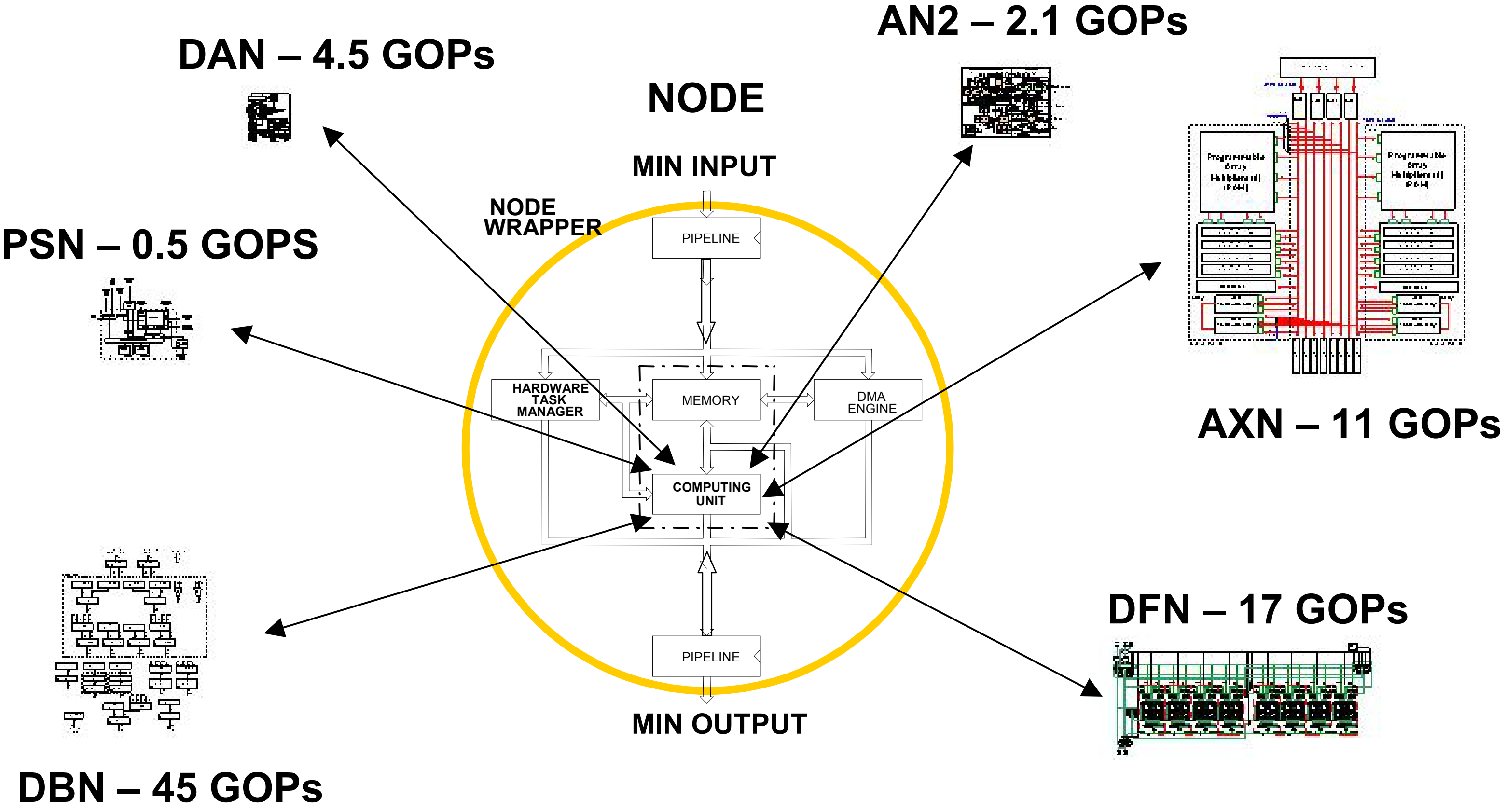


Optimal Solutions : Diverse algorithms require diverse hardware ⇒ **Heterogeneity**

# Abstract Away Differences

Diverse architecture simplified by

**Unified Programming Model**



DAN – 4.5 GOPs

AN2 – 2.1 GOPs

NODE

MIN INPUT

NODE WRAPPER

PSN – 0.5 GOPS

PIPELINE

AXN – 11 GOPs

HARDWARE TASK MANAGER

MEMORY

DMA ENGINE

COMPUTING UNIT

DFN – 17 GOPs

PIPELINE

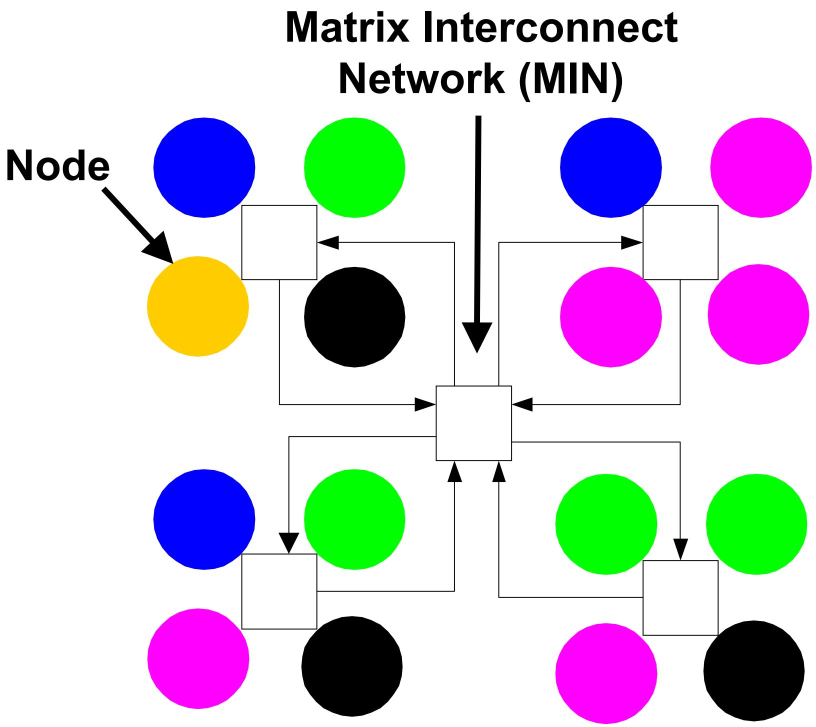
MIN OUTPUT

DBN – 45 GOPs

# Abstract Away Connections

Heterogeneous nodes are connected by a homogenous communications network

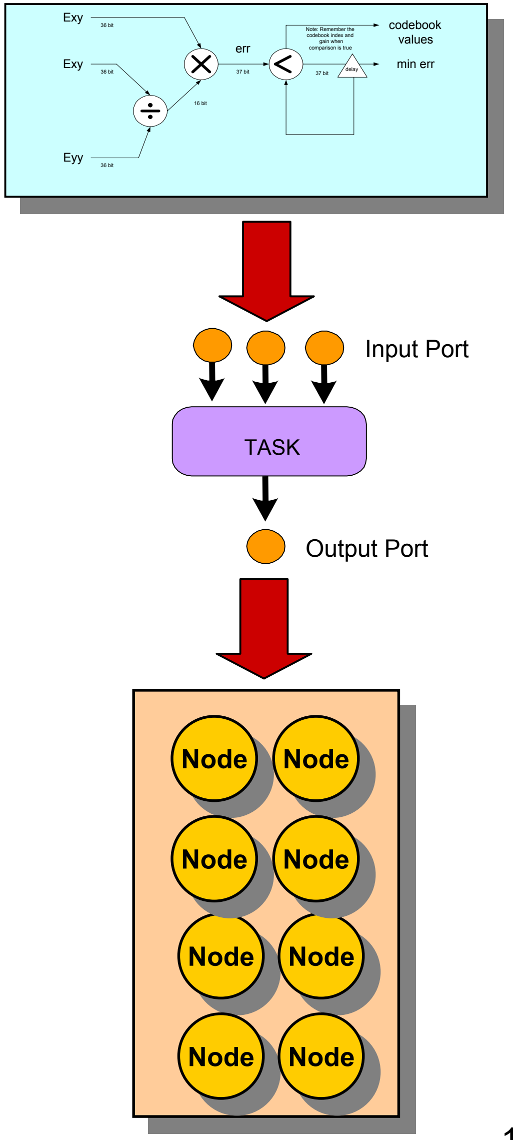
## Matrix Interconnect Network (MIN)



- Point-to-point interconnect for tasks between nodes
- Packet-based
- Scalable from one node to thousands
- Abstracted in the SilverC language/tools – easy to program

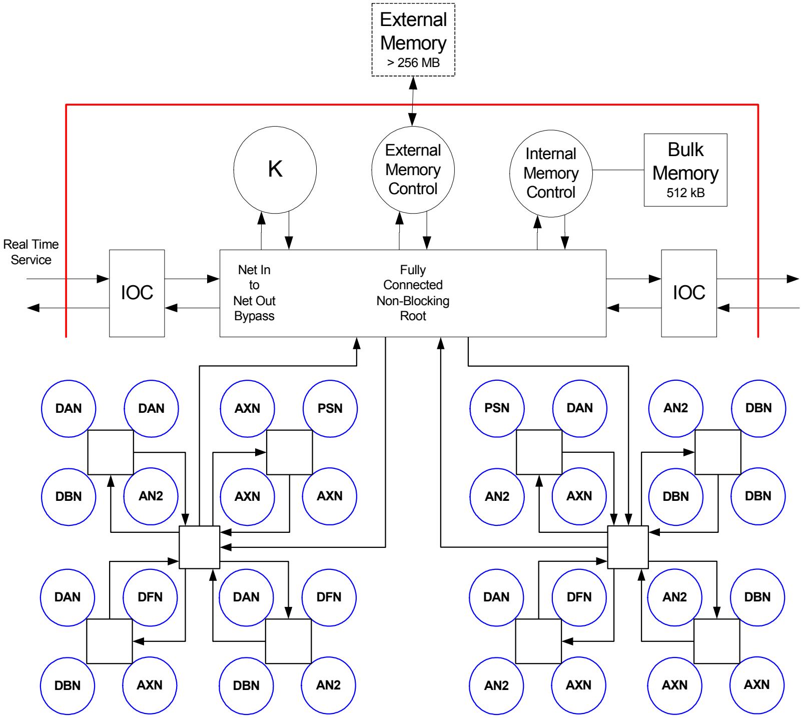
# Abstract Away the Adaptability

- SilverC is a system design language for hardware abstraction
- Algorithms are represented as tasks
- Tasks execute in a dataflow model
- Tasks operate asynchronously
- Abstraction allows tasks to be easily relocated
- OS hides the details of underlying hardware changes & assignments from the programmer



# The ACM: A System

- Abstraction:
  - Heterogeneous nodes
  - Interconnect network(MIN)
  - Tasks
  - Adaptability
  - ALL under a Unified Programming Model



External Memory > 256 MB

K

External Memory Control

Internal Memory Control

Bulk Memory 512 kB

Real Time Service

IOC

Net In to Net Out Bypass

Fully Connected Non-Blocking Root

IOC

DAN DAN AXN PSN PSN DAN AN2 DBN

DBN AN2 AXN AXN AN2 AXN DBN DBN

DAN DFN DAN DFN DAN DFN AN2 DBN

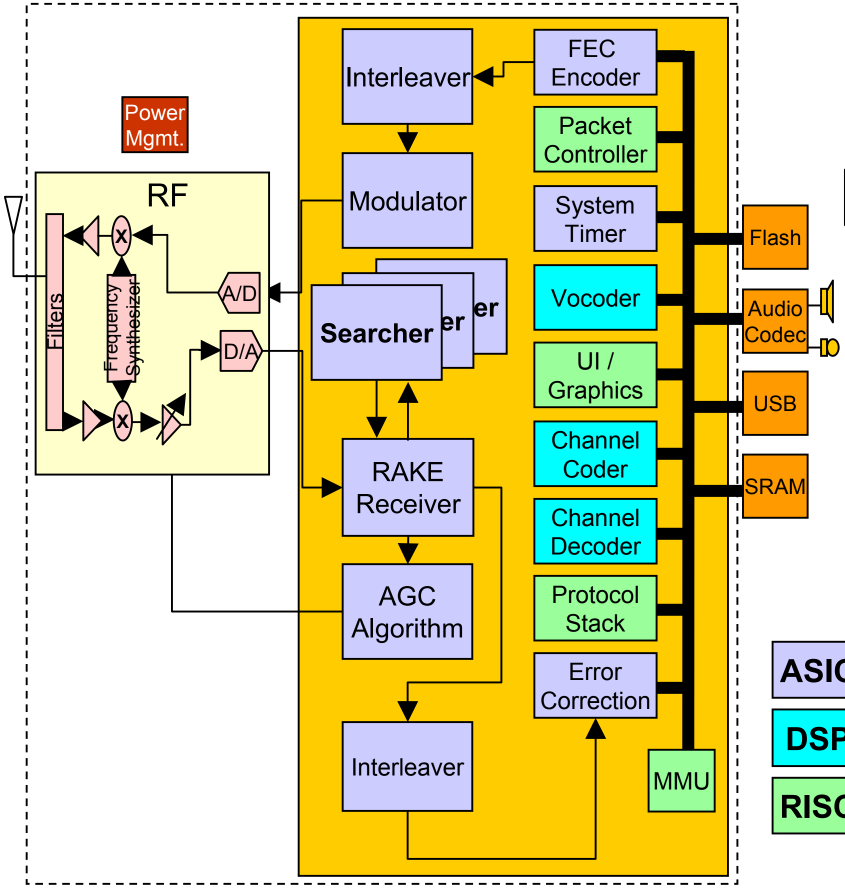
DBN AXN DBN AN2 AN2 AXN AXN AXN

- Impact:
  - Faster,simpler development time for designer
  - Faster time to market
  - Superior performance at low cost, low power consumption

- Enables new/novel applications and services – adapts to any wireless or mobile computing standard

# Handset Example

## Conventional IC Approach



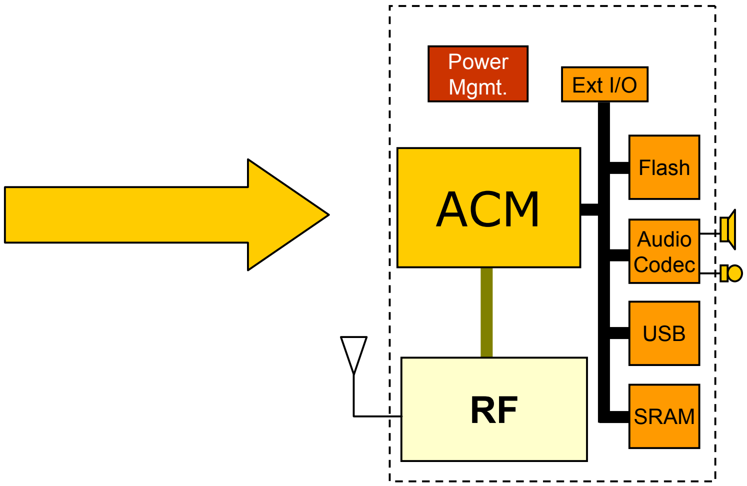
ASIC

DSP

RISC

CDMA

## ACM Approach



| | |
|---|---|
| **Power consumption** | **< 87%** |
| **Die size reduces** | **> 60%** |
| **Performance increases** | **~ 9x** |
| **Design time drops** | **~ 50%** |

MP3

MPEG-4

Bluetooth

GPS

GSM/GPRS

cdma2000

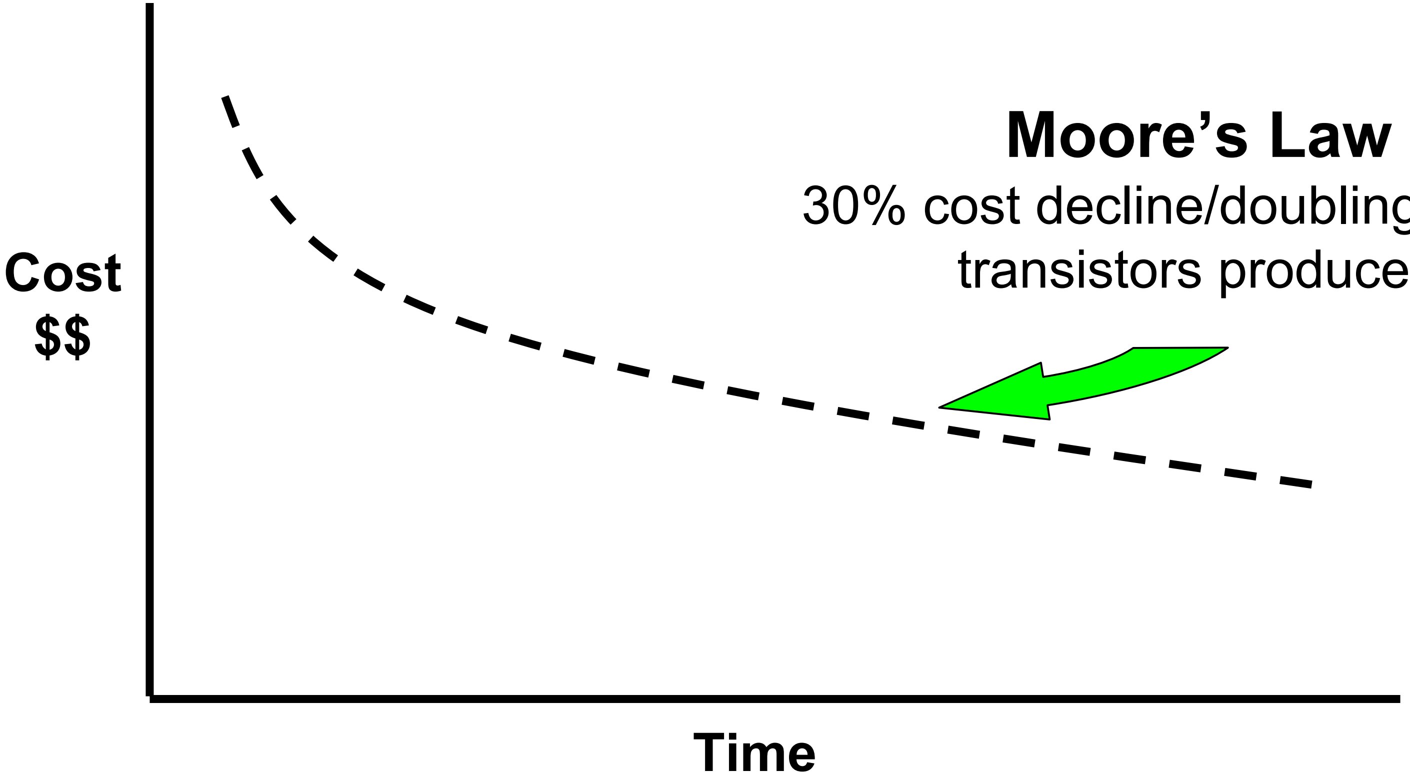
wCDMA

# ACM = The Optimal Solution

- Beats an ASIC
  - Performance, flexibility, time-to-market, and cost (with similar power consumption)
- Beats an FPGA
  - Low power, performance, cost, ease of design
- Beats a DSP or Processor
  - Performance, low power, and cost

**ACM: All Software-Programmable, High Performance, Low Power, Low Cost, Flexible Architecture**

# Moore's Law – Traditional ICs

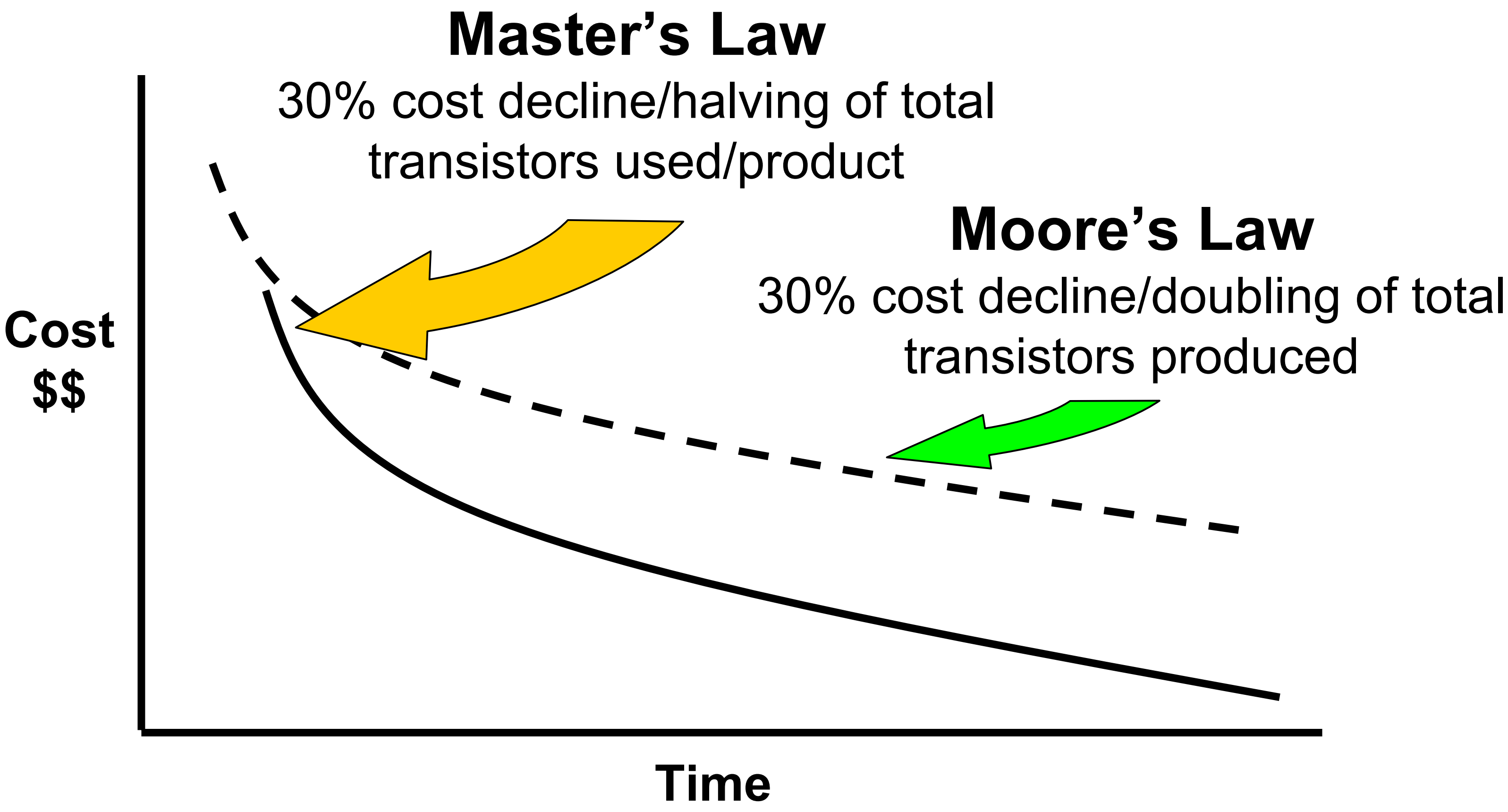


**Moore's Law**

30% cost decline/doubling of total transistors produced

**Transistor costs decline; complexity increases**

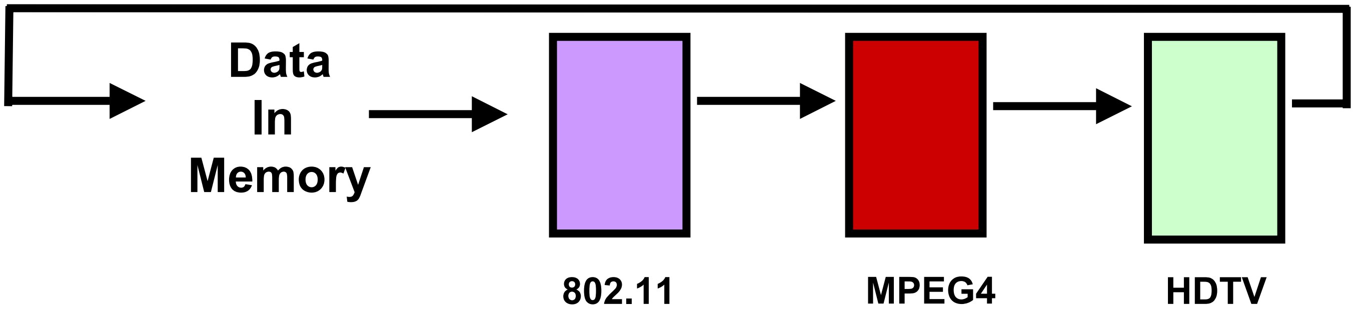
# Master’s Law – New IC Architecture



**Master’s Law reduces the cost and the complexity**

# Example: Master’s Law

## Typical ASIC System Design



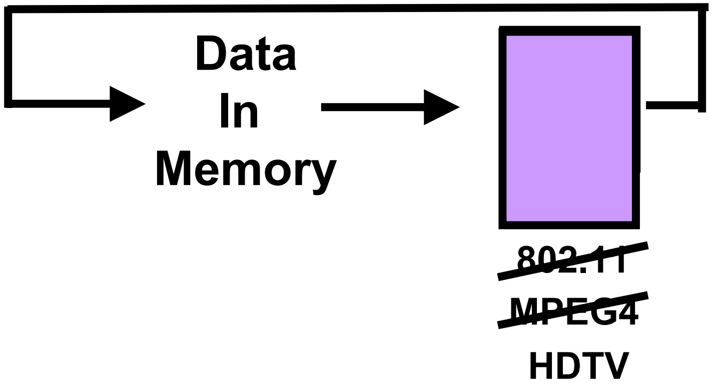
Data In Memory

802.11

MPEG4

HDTV

## ACM – Reuse for different apps



Data In Memory

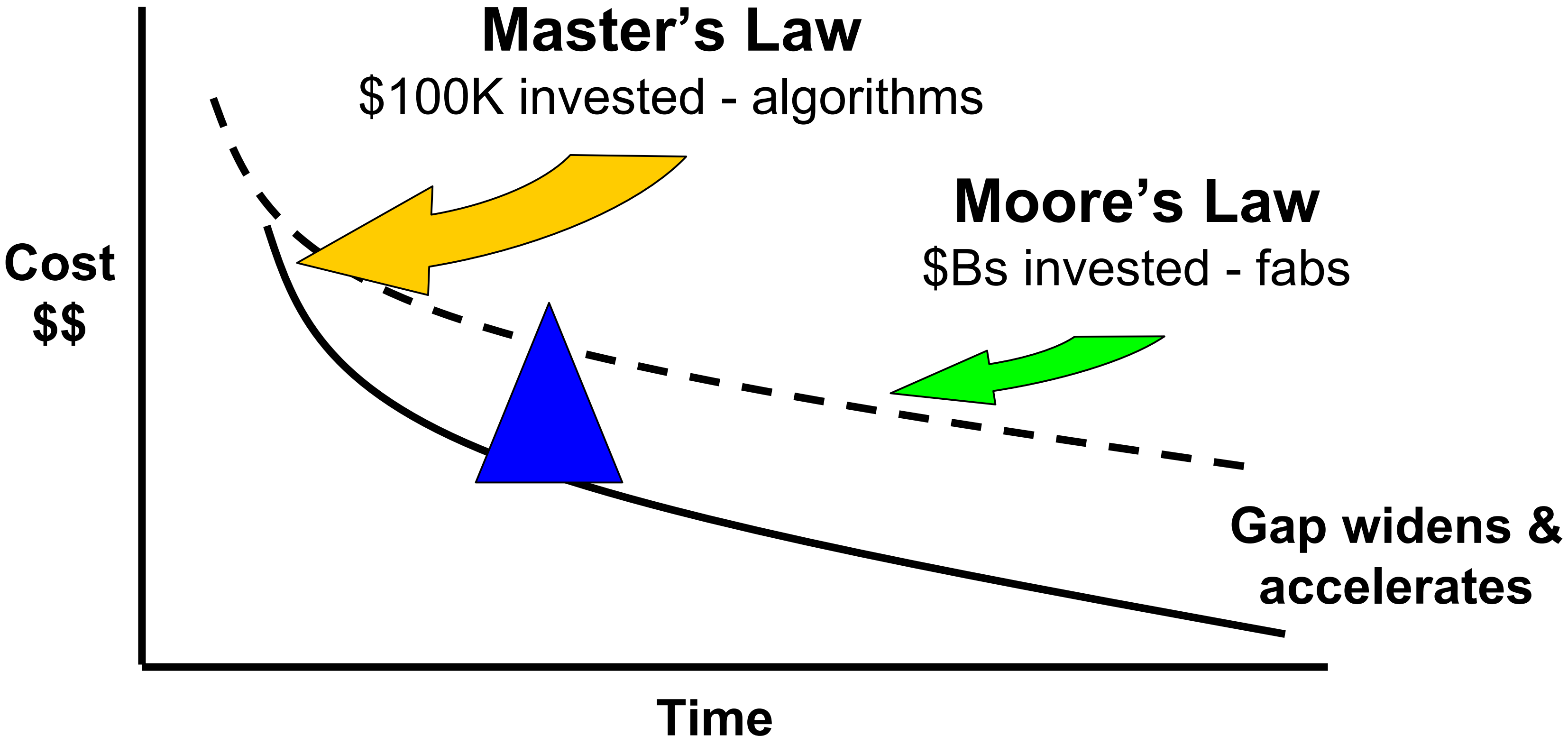
~~802.11~~

~~MPEG4~~

HDTV

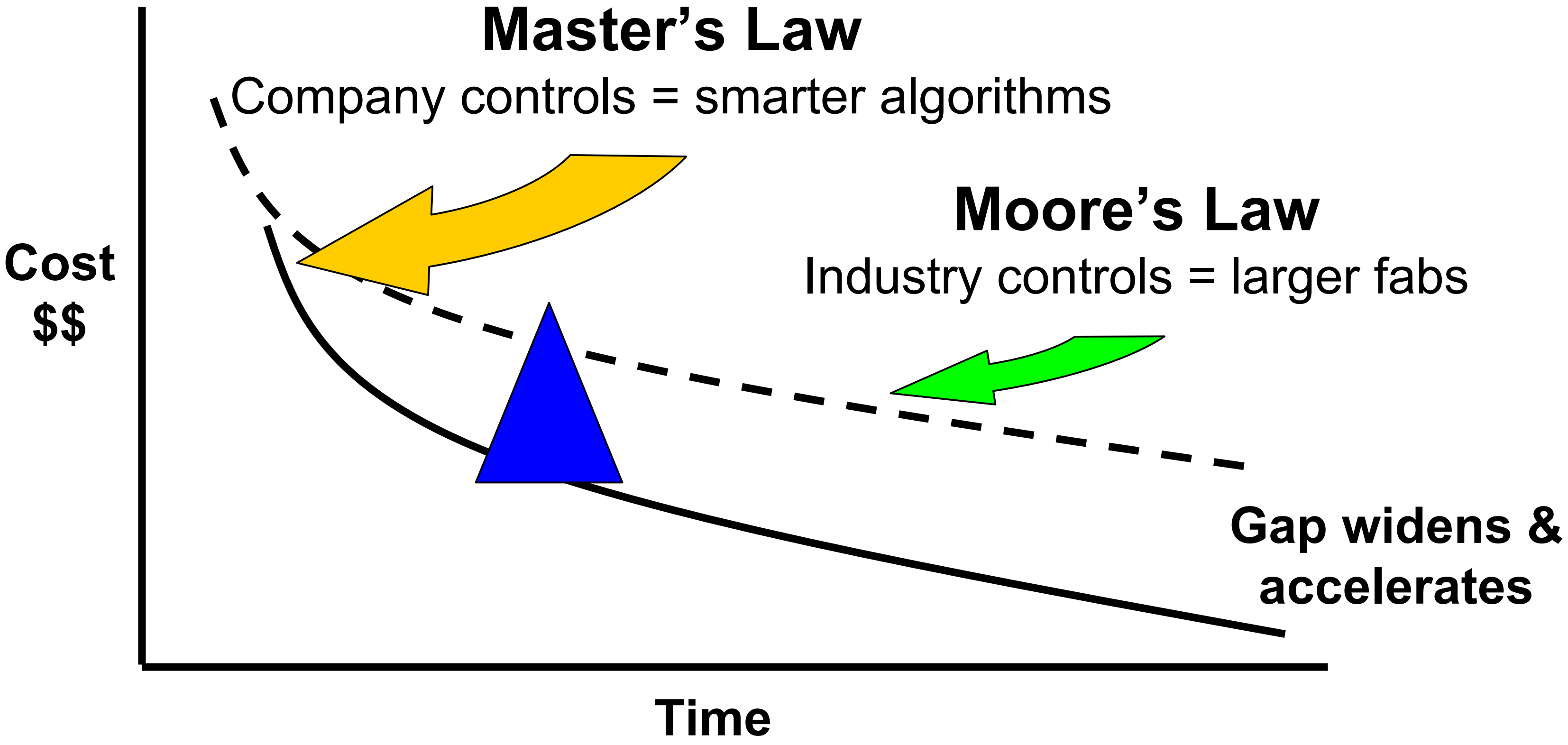
**1/3rd**

# Capital Implications



**Master’s Law changes the capital equation**

# Control Implications



**Master’s Law changes who controls technology progress**

# ACM: Welcome to Eden

- Efficient use of silicon
  - Fewer transistors = high performance, low power consumption, reduced silicon area, & low cost in a single chip
- All software-programmable – architecture flexibility & ease of design
- Lower cost of development
- Faster time to market
- Higher gross margins through software

- **Removes complexities for designers, carriers, users**
- **Consumers can now enjoy an Internet-like experience with wireless/mobile computing**

# Gates to Eden Now Open

ACM deployed 2003

Commercial designs now underway with global companies