# Reducing Standby Power in Networked Appliances

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ARM

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# ARM Activities

- ARM® technology lies at the heart of advanced low-power digital products
- >10 billion processors shipped since 1990
  - 8 million processors per day
- The ARM Connected Community is a network of more than 400 supporting companies in the embedded-electronics supply chain
- ARM supplies processor designs; our Partners make ARM Powered® products around them

# Are Your Appliances Plugged in Now?



*Of the $250 billion spent globally each year powering computers, about 85% of that energy is simply wasted idling*

**Stand by me**
Standby-power use ranges of home appliances 1999, watts

Minimum    Average    Maximum

**Pulling the plug on standby power**

study in France found that standby power accounted for 7% of total residential consumption. Further studies have since come to similar conclusions in other developed countries, including the Netherlands, Australia and Japan. Some estimates put the proportion of consumption due to standby power as high as 13%.
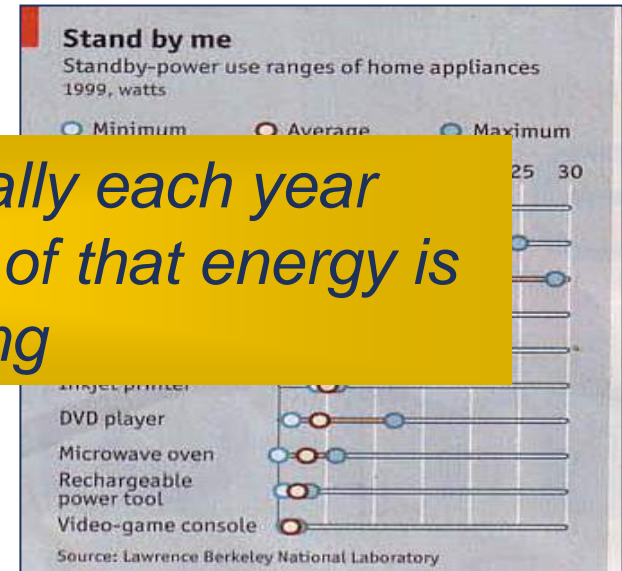
The wasted energy, in other words, is equivalent to the output of 18 typical power stations.

Silent Thievery

Sources: *Economist*, March 11, 2006;
Pat Gelsinger, SVP Intel digital enterprise group

# UK Standby Examples

- "A survey by the Energy Saving Trust found that the average household has up to 12 gadgets left on standby or charging at any one time. It also showed that more than £740m of electricity was wasted by things being left ticking over"

- "Last June, Environment Minister Elliot Morley, responding to an MP's question, revealed that electrical equipment in sleep mode used roughly 7TW of energy and emitted around 800,000 tonnes of carbon"

- "TV 'sleep' button stands accused," by Mark Kinver, BBC News science and nature reporter

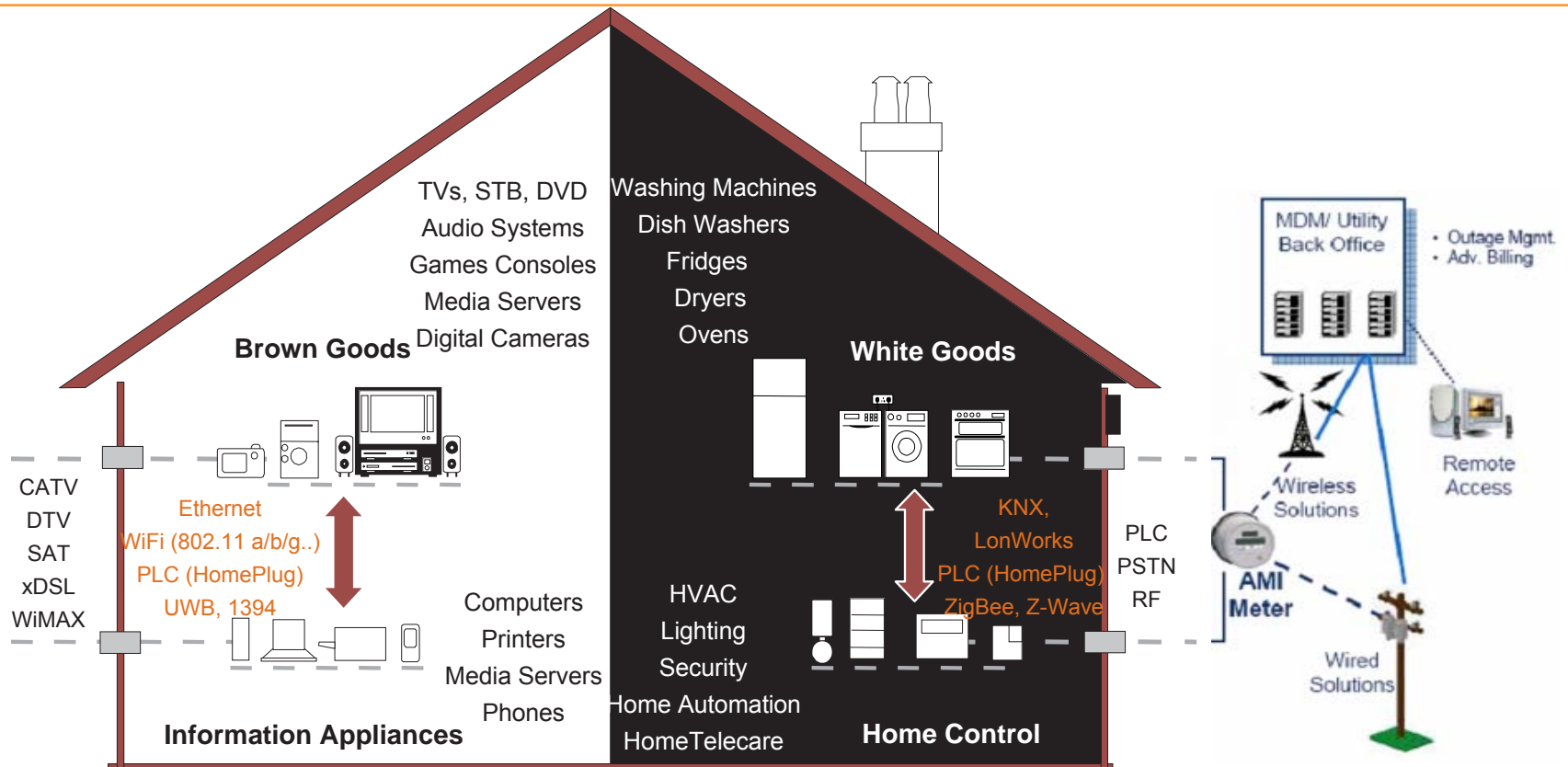# Move to New Low Power Intelligence

- *Old habits + old technology = predictable consequences*

- *Old habits + new technology = dramatically altered consequences*

*Al Gore, "An Inconvenient Truth"*

# The Connected Home



- Consumer electronics will account for 45% of domestic electricity usage by 2020 – electronics must become more efficient!

- TAHI organization working toward interoperability in the digital home network – this will reduce power
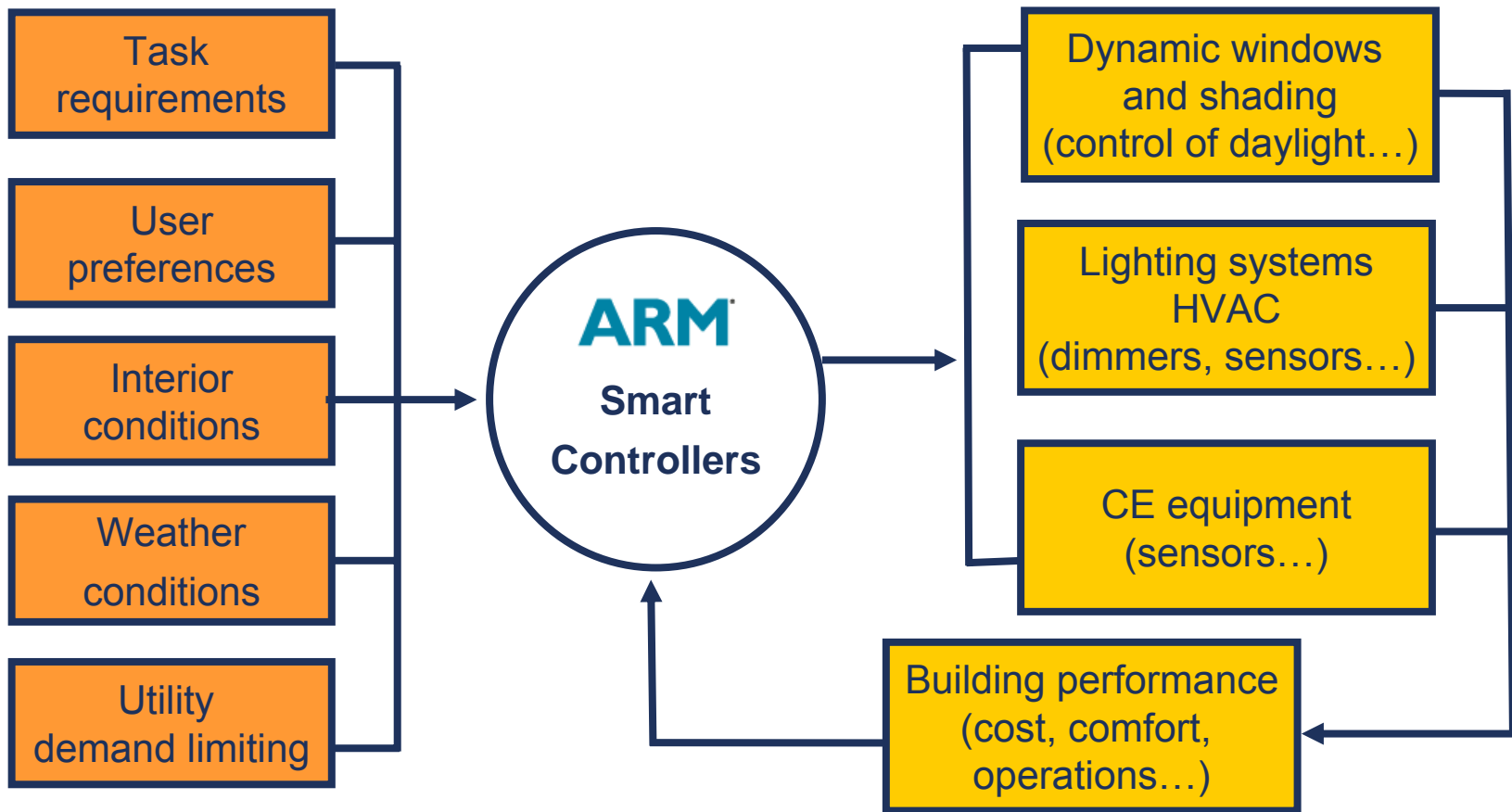
# PowerDown



Say goodbye to standby.

- PowerDown is a 3-way energy-saving plug designed for use with desktop PCs
- Master socket controls power to two slave sockets
- When the PC is switched off, PowerDown automatically turns off the power to any equipment connected to the PowerDown

# Intelligent Control of Home Systems

Task requirements

User preferences

Interior conditions

Weather conditions

Utility demand limiting

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**Smart Controllers**

Dynamic windows and shading (control of daylight…)

Lighting systems HVAC (dimmers, sensors…)

CE equipment (sensors…)

Building performance (cost, comfort, operations…)

- Tomorrow's energy efficient homes will require additional processing performance at all levels of their infrastructure
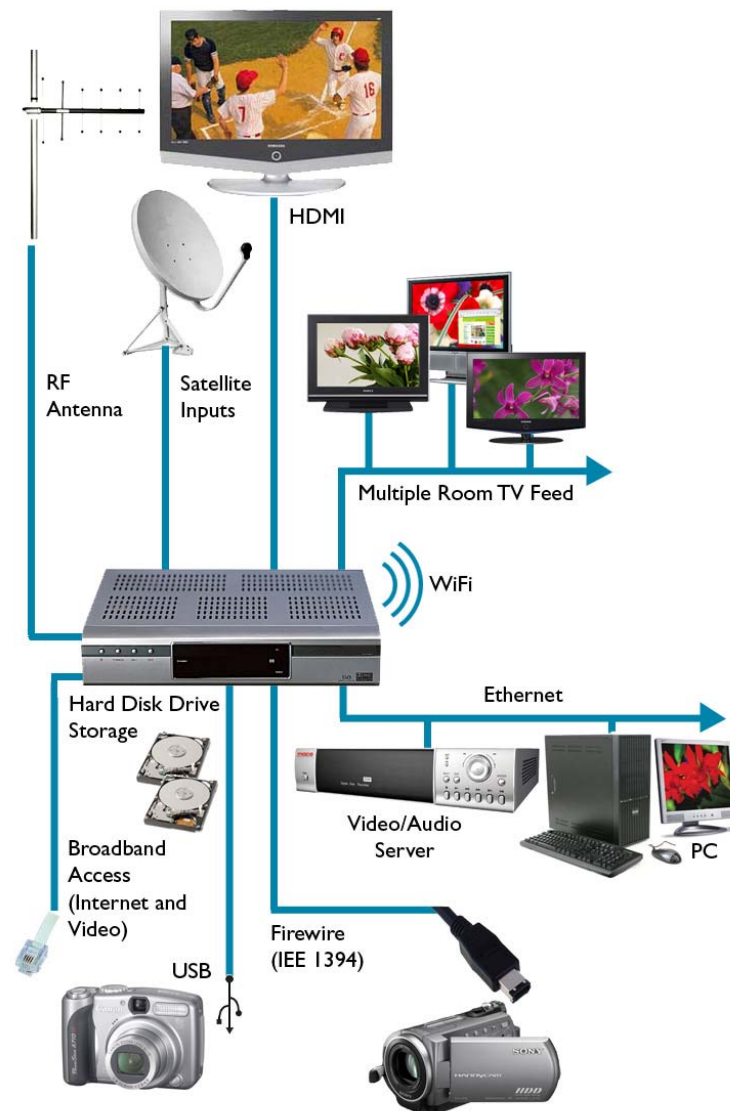
# Energy Savings at All Levels
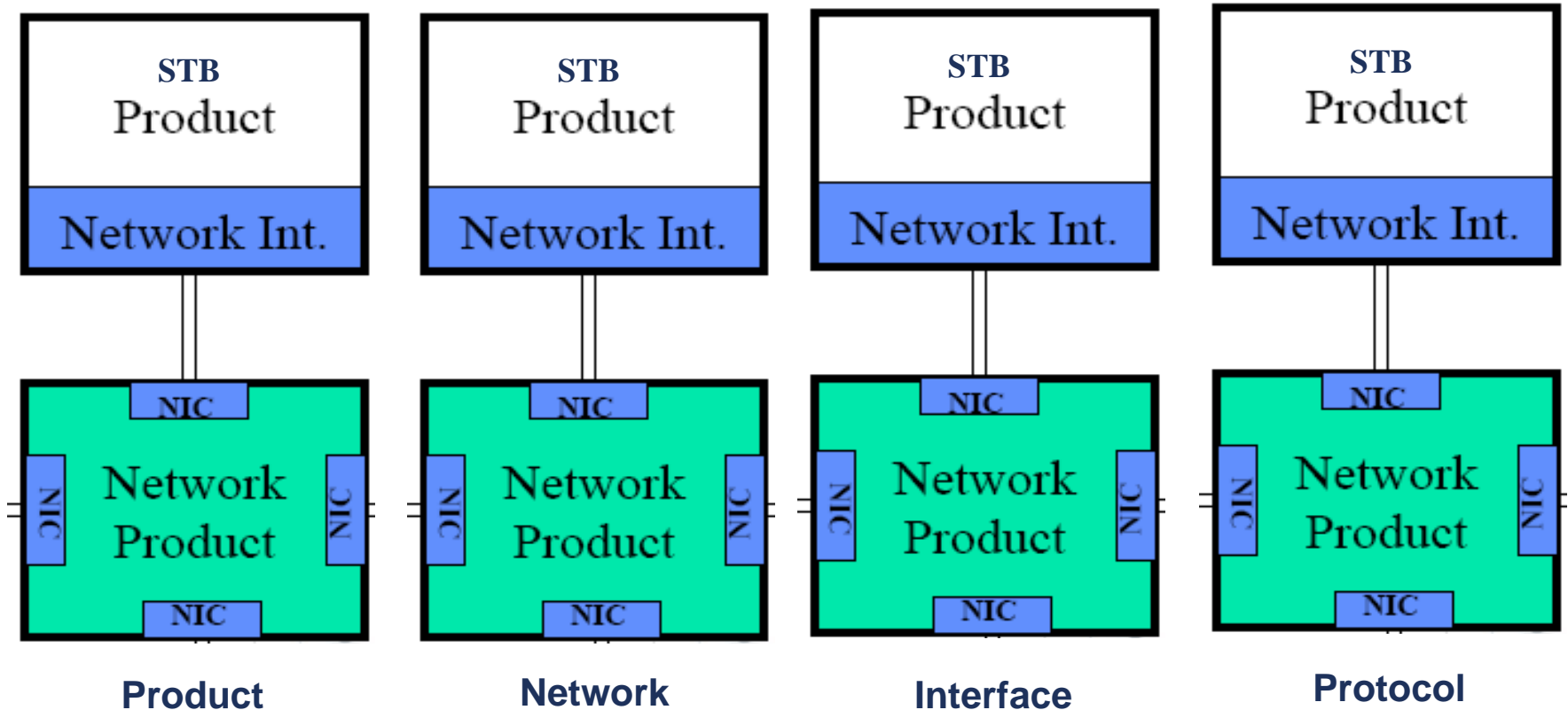


- Efficient active modes
- Efficient interfaces / links
- Power-aware protocols
- Activity minimization
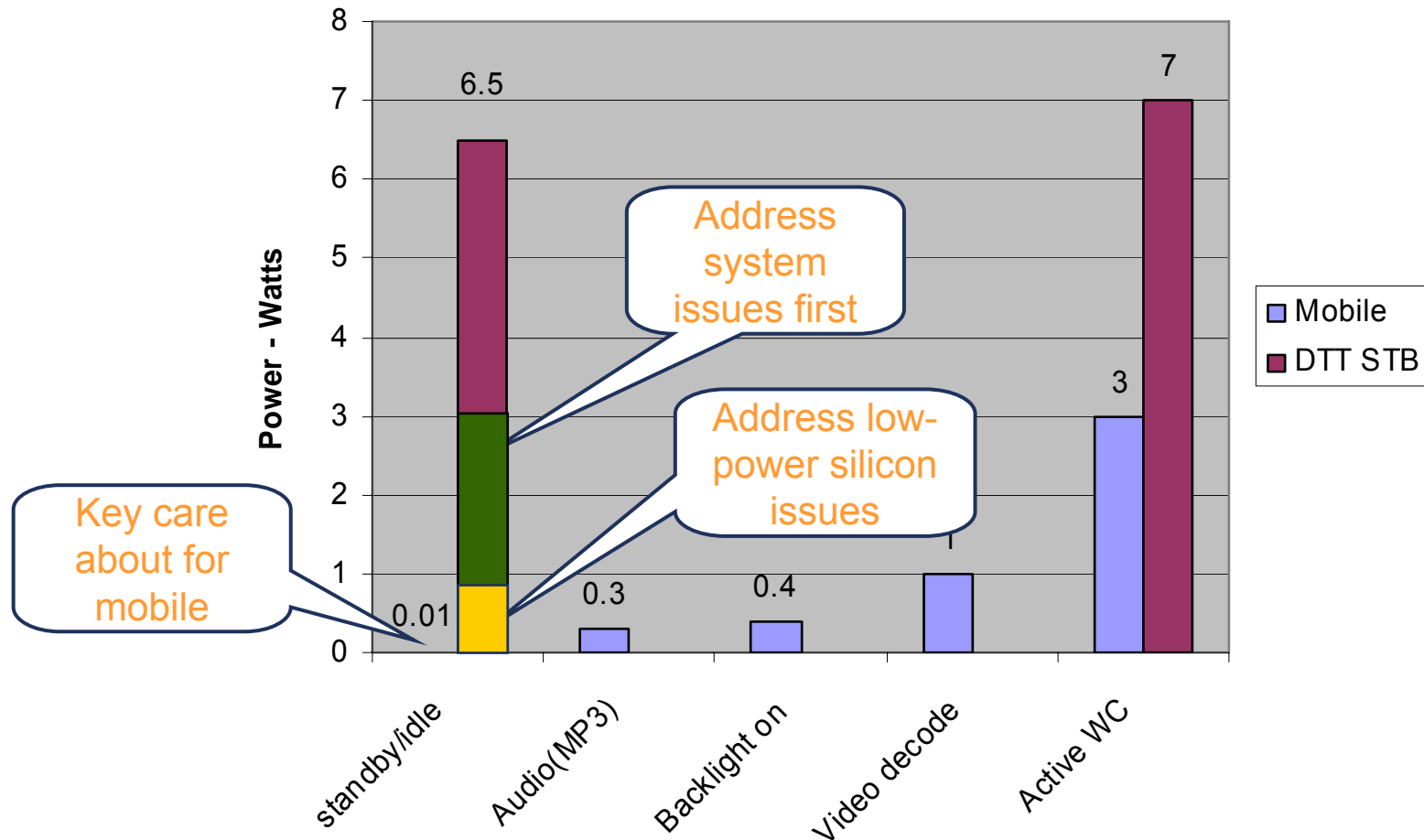
# The Complex STB

- Greater functionality can require more power

- More tuners

- Home networking connectivity
  - STBs active on multiple networks
  - Multi-stream DCAS / DRM

- Increased decode capability

- Need high-performance, low-power processing!



HDMI

RF Antenna

Satellite Inputs

Multiple Room TV Feed

WiFi

Hard Disk Drive Storage

Ethernet

Broadband Access (Internet and Video)

Video/Audio Server

PC

Firewire (IEE 1394)

USB

# 3 Areas For Possible Efficiency Gains

- The system on chip (SoC)
  - By copying technology used in mobile phones, ARM Powered® STBs could reduce standby power to < 1W
  - Will require cooperation from everyone in the development and deployment chain
- The client software that runs on the STB
  - Powering down tuners when not in use
  - Powering down blocks within SoC when not in use
- The networks that are connected to the STB
  - Monitoring presence
  - Powering down home connectivity when not in use
  - Minimizing the frequency of communications/pings

# Mobile Phone Power v. DTT STB



Efficiencies can approach mobile phone levels with cooperation from all players

# Moore's Law – Driving Semi Industry

- "The complexity for minimum component costs has increased at a rate of roughly a factor of two per year" – Gordon E. Moore, *Electronics*, April 19, 1965

  - Based on empirical observations 40+ years ago

  - Smaller transistors on larger wafers → massive increase in performance at much lower power

  - ARM has been at the forefront of low-power electronics since 1990

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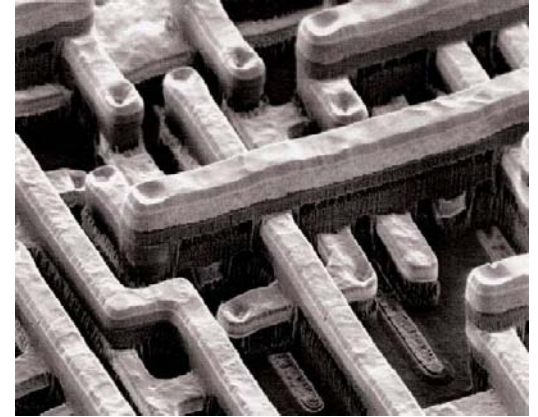
# Implications of Moore's Law

- Finer process geometries
    - Lower costs
    - More, new functionality
    - Better power efficiency
    - Less space
    - Better reliability
    - Lots more memory on chip



Apollo Guidance Computer
(c. 1968)
~20k components; 8kB RAM;
16-bit ALU

More than 10 billion ARM processors reducing the world's carbon footprint



2GB Flash card -> 16Gbits

1 to 15 billion transistors

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# ARM Enables Low-Power Intelligence





- World's 2.3 billion mobile phones draw 100 Mega-Watts per day
  - Equivalent to 2 large wind farms

- World's 1 billion PCs are on for ~9 hours per day drawing 95,000 Mega-Watts per day
  - Equivalent to 114 large coal-fired (835MW) power plants

Mobile design is traditionally low power;
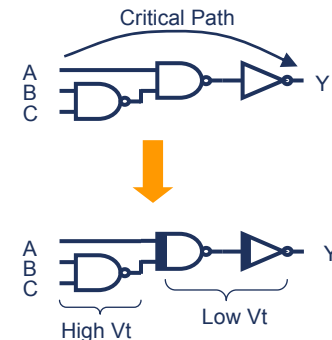the opportunity lies in wired design

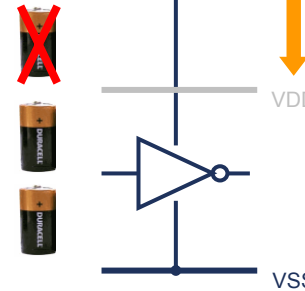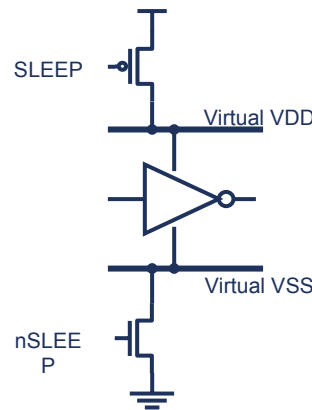**ARM**®

# Power Management Techniques
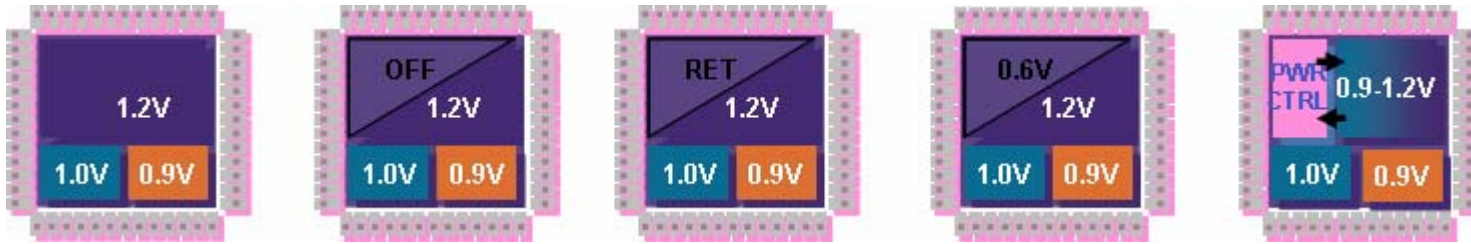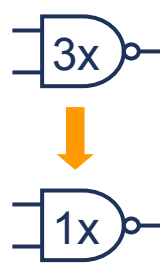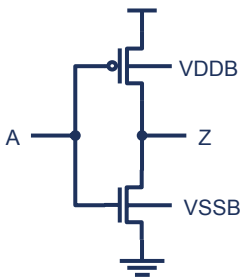


| Multi-Voltage (MV) | MTCMOS Power Gating (shut down) | Power Gating with State Retention | Low-VDD Standby | Dynamic or Adaptive Voltage Frequency Scaling (DVS, DVFS, AVS, AVFS) |
|---|---|---|---|---|

Variable $V_{TH}$ (Back Bias – P/N)

Cell Sizing

Power Gating

Lower Operating Voltage

Dual $V_t$

## Can result in >2x savings in dynamic power and 10x reduction in leakage power

# Low-Power ARM Products
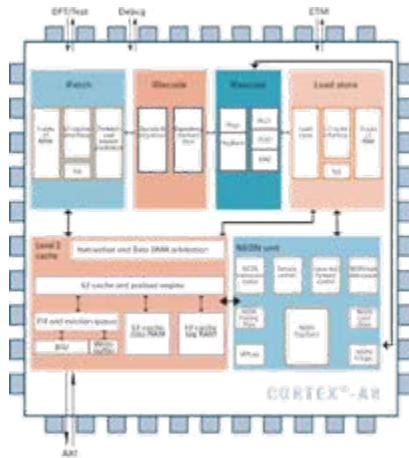
ARM Cortex™ Processors
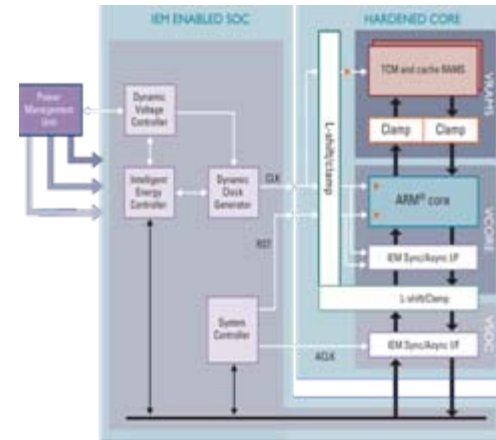
Intelligent Energy Management (IEM™) DVFS Technology

ARM Artisan® Libraries and Power Management Kit
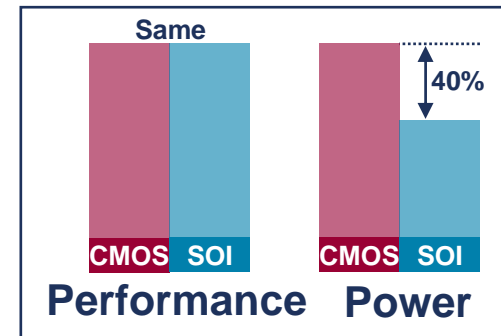
Silicon On Insulator Libraries and Memories

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# Something Must Change!

Improving power efficiency during usage as well as during standby



Power Density Extrapolation

CPU - Computer Power User Magazine
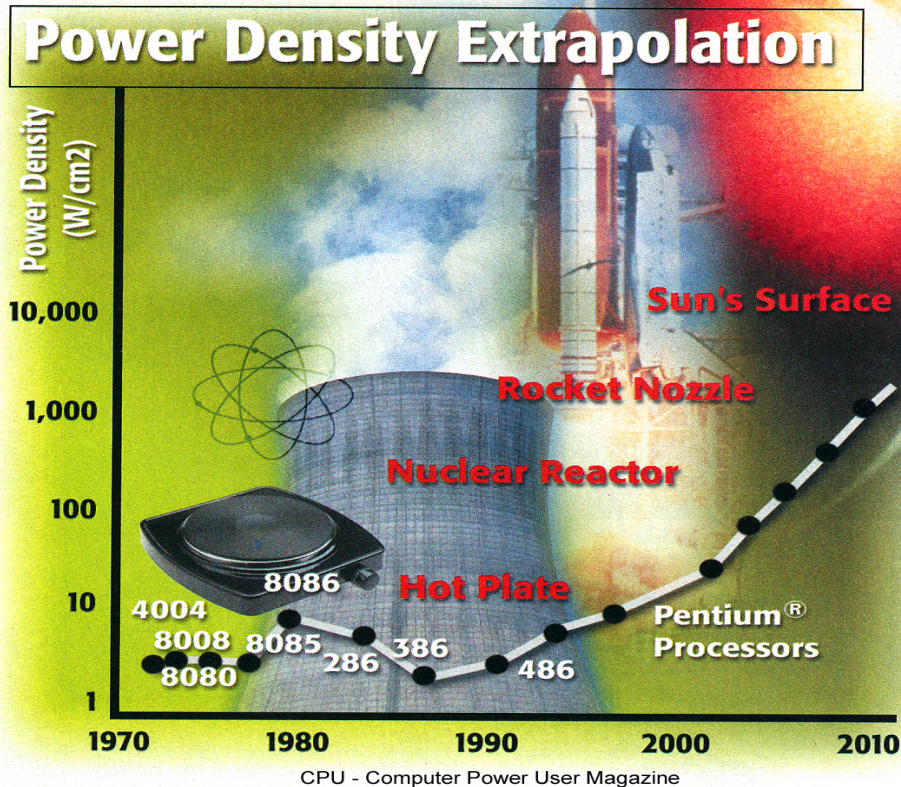
# Investing in Multiprocessing

- Multiple processor cores = greatly improved performance without a large increase in power used

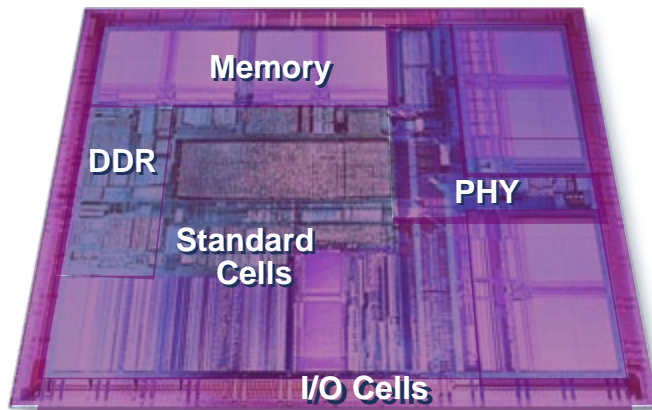- ARM was first in multiprocessing

- Multiprocessing offers the flexibility of both high performance and low power

  - Many ARM processor-based SoCs today already have multiple processors

  - ARM11™ MPCore™ multicore processor has more than ten licensees developing chips for printers, HDTV, DSC, networking, and more

- New Cortex-A9 processor to bring multiprocessing to all

  - Upgrade path for ARM11-family products

  - Software compatibility with Cortex-A8 processor

# Texas Instruments - OMAP

| | OMAP | OMAP 2 | OMAP 3 |
|---|---|---|---|
| Process Technology | 130nm→90nm | 90nm→65nm | 65nm→45nm |
| ARM Core | 926 v5 | 1136 v6 | Cortex A8 v7 |
| Power per Task | | Up to 40% less than OMAP | Up to 30% less than OMAP 2 |
| Multimedia Accelerator | DSP 55x™ | DSP 55x™+ IVA 2D/3D hardware | IVA 2+ 2D/3D hardware |
| Display | QVGA | VGA | XGA |
| Camera | 2 mega-pixel | 6 megapixel | 12 megapixel |
| Video Playback | QVGA | VGA→DVD | DVD→HD |
| Video Camcorder | QVGA | VGA→DVD | DVD |
| Video-conferencing | QCIF | CIF | VGA |

- Exhaustive use of power and performance management technologies
  - Intelligent and adaptive hardware and software techniques that dynamically control voltage and frequency based on device activity, modes of operation and temperature

SmartReflex™
Power & Performance Management Technology

TEXAS INSTRUMENTS

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# Enabling Low Power through Partners

- **Conexant SoCs for high-end dual TV and gateway set-top boxes**
  - Multi-room viewing, watch and record on two separate TVs from a single set-top box

- **Low-power ARM11 and ARM9™ families at the heart of SoCs**
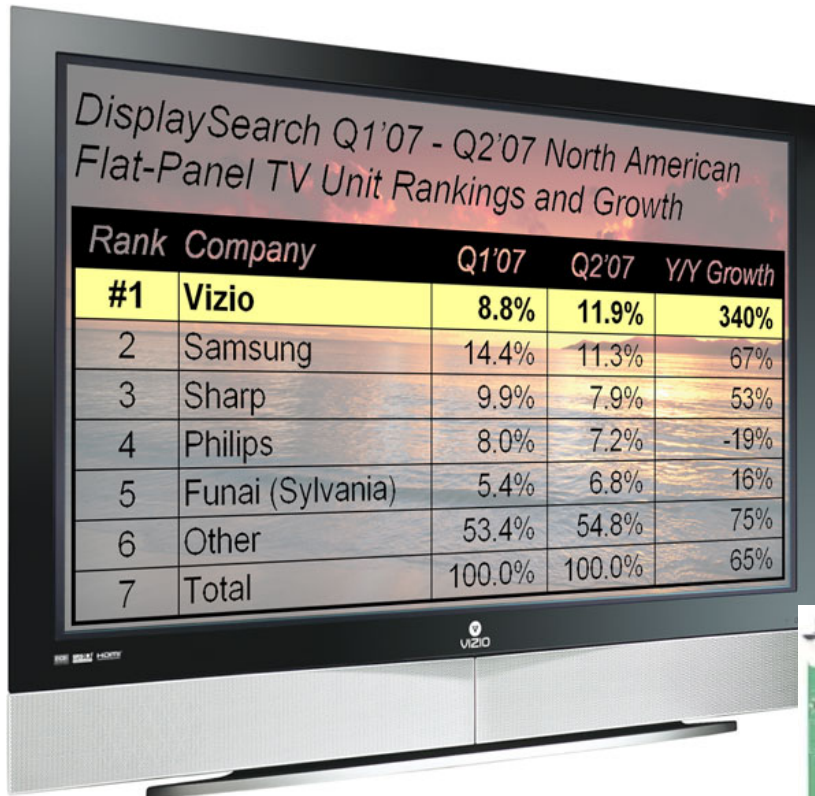
- **Chips in use in DirecTV, DISH Network and Sky boxes**



Conexant Cable SOC
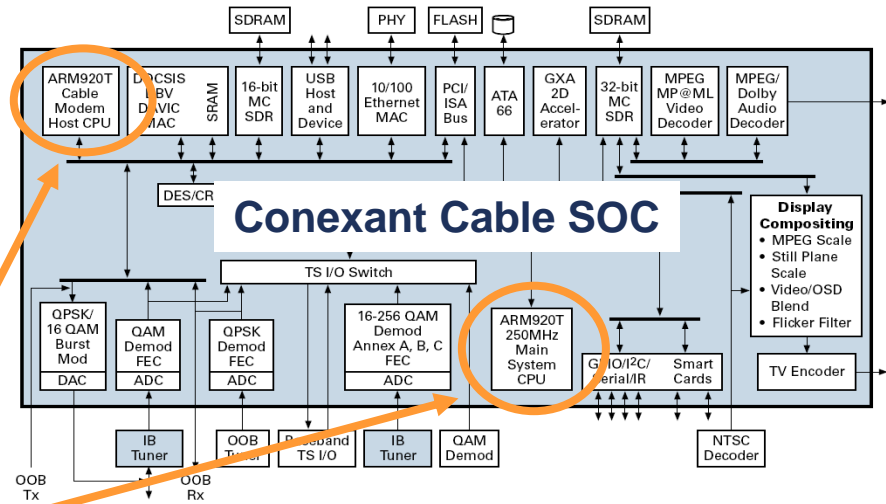


$CO_2$ savings of 32,000 tonnes

Auto-Standby

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# ARM Enables Low-Power TV: Vizio



DisplaySearch Q1'07 - Q2'07 North American Flat-Panel TV Unit Rankings and Growth

| Rank | Company | Q1'07 | Q2'07 | Y/Y Growth |
|------|---------|-------|-------|------------|
| #1 | Vizio | 8.8% | 11.9% | 340% |
| 2 | Samsung | 14.4% | 11.3% | 67% |
| 3 | Sharp | 9.9% | 7.9% | 53% |
| 4 | Philips | 8.0% | 7.2% | -19% |
| 5 | Funai (Sylvania) | 5.4% | 6.8% | 16% |
| 6 | Other | 53.4% | 54.8% | 75% |
| 7 | Total | 100.0% | 100.0% | 65% |

iSuppli Teardown Report
Vizio 40-inch DTV
(Mediatek/ARM Chip)

MT5351AG
0649-BCSL
KHK16
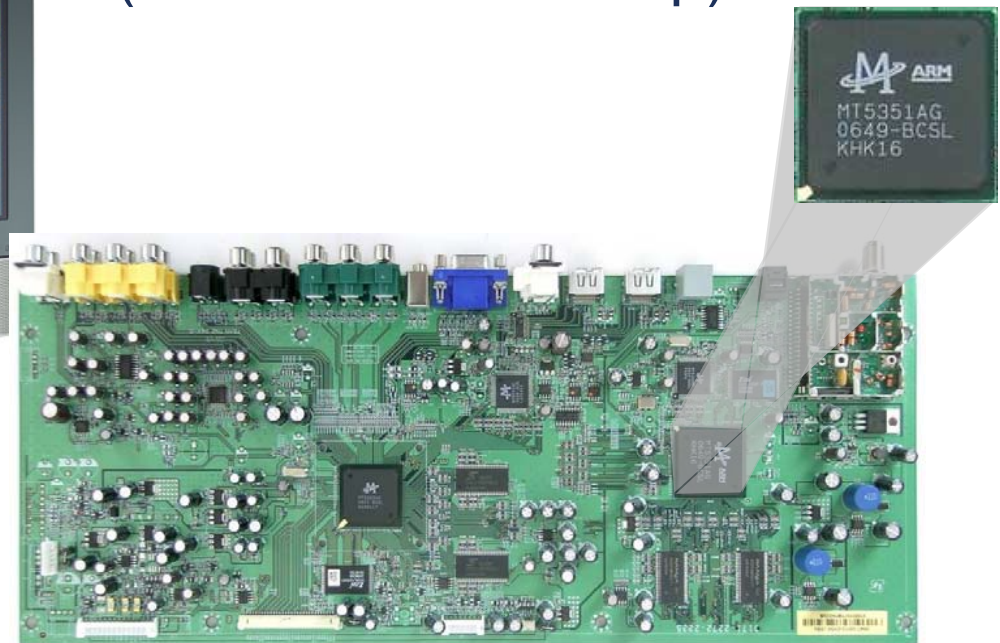
# ARM Enables Low Power Connectivity

- >60% WiFi and >90% WiMAX devices are ARM Powered

| | | | | | |
|---|---|---|---|---|---|
| **InTellon** NO NEW WIRES | **MARVELL** | **LSI** | **MNDSPEED** BUILD IT FIRST | **BROADCOM** | **intel** |
| HomePlug | WiFi, Gateway, Home Storage | Home and SMB Gateway | Home and SMB Gateway | WiFi, Bluetooth | Home Gateway, WiMax |
| **picoChip** flexible wireless | **ST** | **SEQUANS** Communications | **CONEXANT** | **NXP** Founded by Philips | **TEXAS INSTRUMENTS** |
| WiMAX, Femtocells | WiFi | WiMAX | Home Gateway, WiFi | UWB, WiFi | Bluetooth, WiFi |

- ARM well established as control plane CPU for connectivity applications
  - Majority of Bluetooth and WiFi vendors use ARM solutions
  - Low power, easy to integrate, good development tools
- ARM roadmap ensures a migration path for low-power, cost-sensitive applications
- Most major networking silicon providers have licensed ARM processors
  - Future devices in development   **TEXAS INSTRUMENTS**  **Avago** TECHNOLOGIES  **ST**  **IBM**

# The Opportunity

- ARM can make a difference across a whole range of CE products, intelligently managing energy efficiency across a range of performance points…

  - Energy efficient 32-bit processor performance, from the Cortex-M3 to the multicore Cortex-A9

  - Low-power Metro™ libraries as well as

  - Intelligent Energy Management and Power Management Kits

  - Tools and software that seamlessly work together

  - Additionally, we leverage our Connected Community to provide complete low power solutions for products based on the ARM architecture, and hence reduce emissions produced by our customers' products

# Finally

"If we fail to dare, if we do not try, the next generation will harvest the fruit of our indifference: a world we did not want, a world we did not choose, but a world we could have made better by caring more for the result of our labor"

*Robert F. Kennedy*