LongRun™
Adaptive Power Control

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Agenda

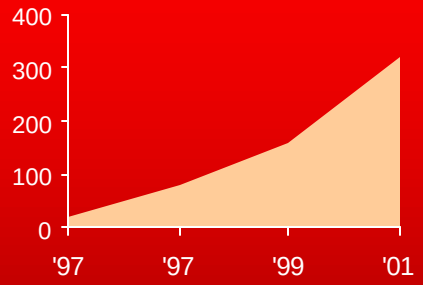
- Key Challenges for Mobile Computing
  - "Portability" and "ease of use"
  - ⇨ Power is the fundamental problem
- Crusoe™ TM3120
  - Full compatibility with traditional x86 power management model
  - At significantly lower power
- Crusoe™ TM5400
  - LongRun™ Adaptive Power Control

Market Trends

The Internet Transforms the PC Market

Growth

Internet Users (mls)



Projected Growth

143%

1999-2002

Source: Dataquest 3/99

Capabilities

Thin & lights and Mini-Notebooks will be 65% of market by 2002

Thin & light becoming even thinner: 1-1.5" today .85-1.25" in 2002

User Demands

Ease of use
93% say their battery "doesn't last long enough"

Portability
82% say their systems are "too heavy"

Source: IDC 12/99

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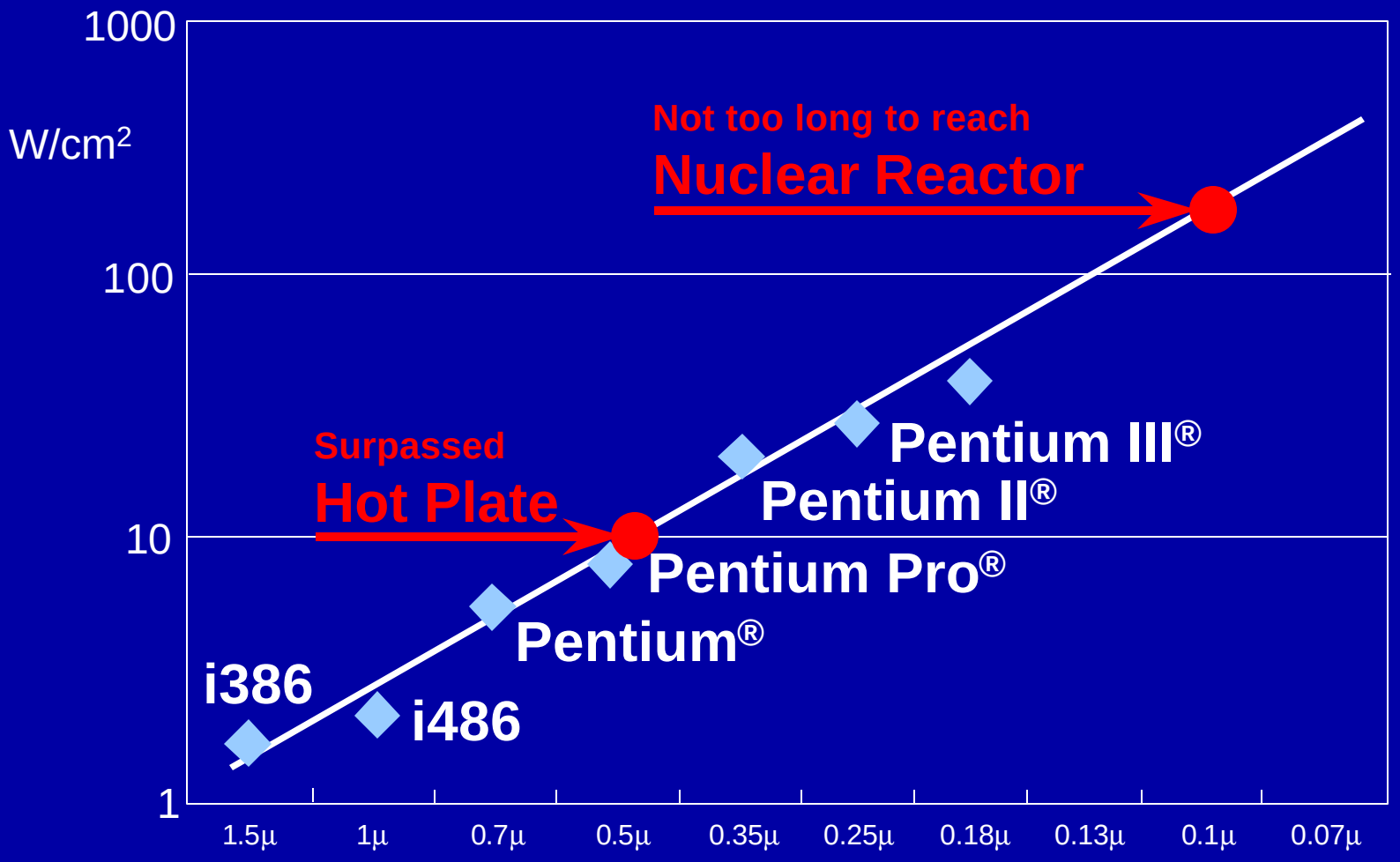
The Problem ... Power Density



Source: Fred Pollok, Intel. New Microprocessor Challenges in the Coming Generations of CMOS Technologies, Micro32

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The Solution ... Use Software

The Software-Based Microprocessor

$$Power = c \times v^2 \times f$$

- Innovation - Code Morphing™ Software
- Effect - Replace Millions of Logic Transistors
  - ... and transistors translate into capacitance (c)
- Benefit - Significantly Reduces Power Consumption of x86 Power States

Traditional x86 Power Management
Crusoe Delivers Substantial Power Reduction

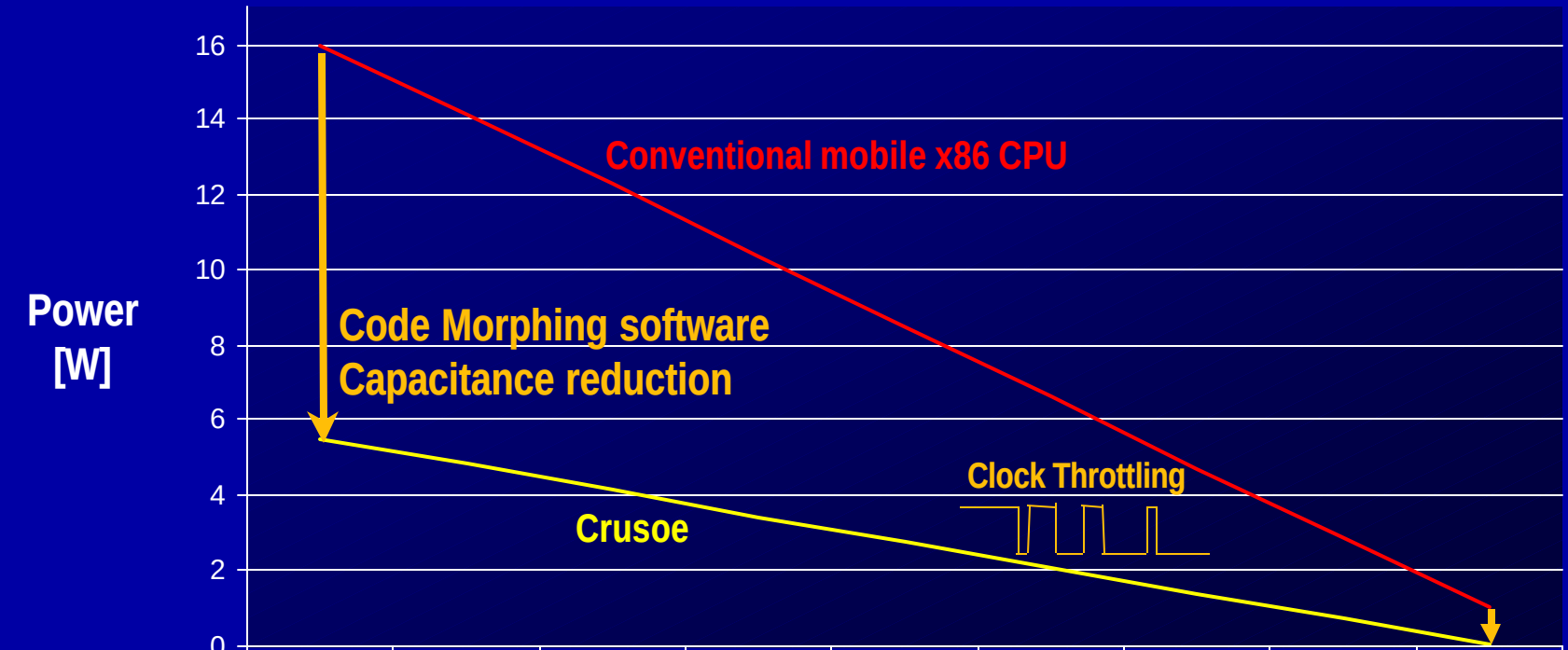
	Conventional Mobile x86 Solution			Crusoe™ Integrated North Bridge	
	Processor 650 / 500 MHz 1.6 / 1.35 V	**North Bridge** 1.35 V	**Total**	**TM3120** 400 MHz 1.5 V [1]	**TM5400** LongRun™ 667 ⇔ 266 MHz 1.65 ⇔ 1.2 V [1]
Normal (C0)	14.0/8.0 W	2.0 W	16.0/10.0 W	3.5 W	5.5 ⇔ 1.5 W
AutoHALT (C1)	1.1 W	2.0 W	3.1 W	0.9 W	0.9 W
Quick Start (C2)	0.8 W	2.0 W	2.8 W	0.4 W	0.3 W
Deep Sleep (C3)	200 mW	700 mW	900 mW	20 mW	30 mW

Notes

[1] TM3120 production silicon, TM5400 pre-production silicon

Traditional x86 Power Management

Crusoe Delivers Substantial Power Reduction



	Normal	12.5%	25.0%	37.5%	50.0%	62.5%	75.0%	87.5%	C3
Conventional	16.0	14.1	12.3	10.4	8.5	6.6	4.8	2.9	1.0
TM5400+NB	5.5	4.8	4.1	3.5	2.8	2.1	1.4	0.7	0.1

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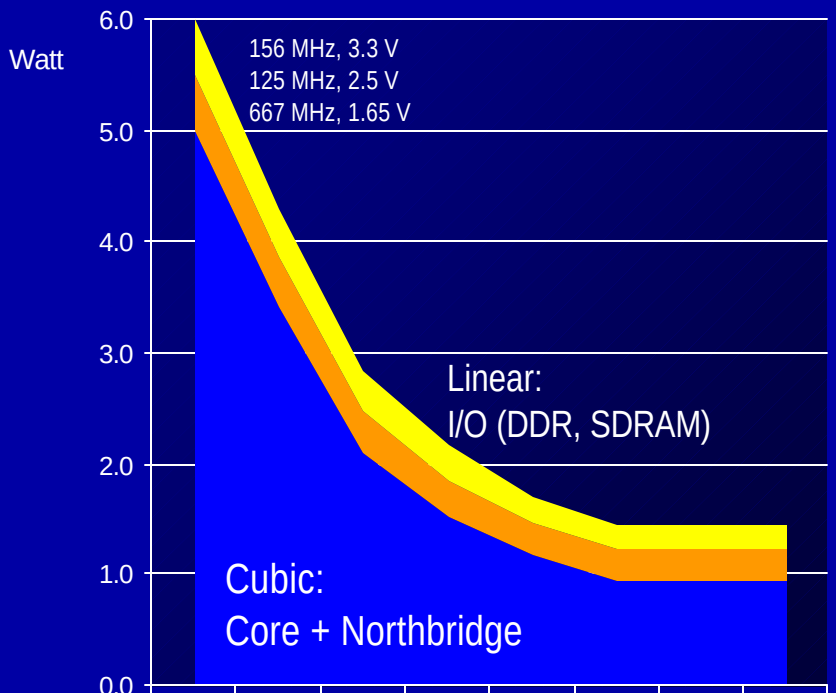
LongRun Adaptive Power Control

Maximize Battery Life with Performance on Demand

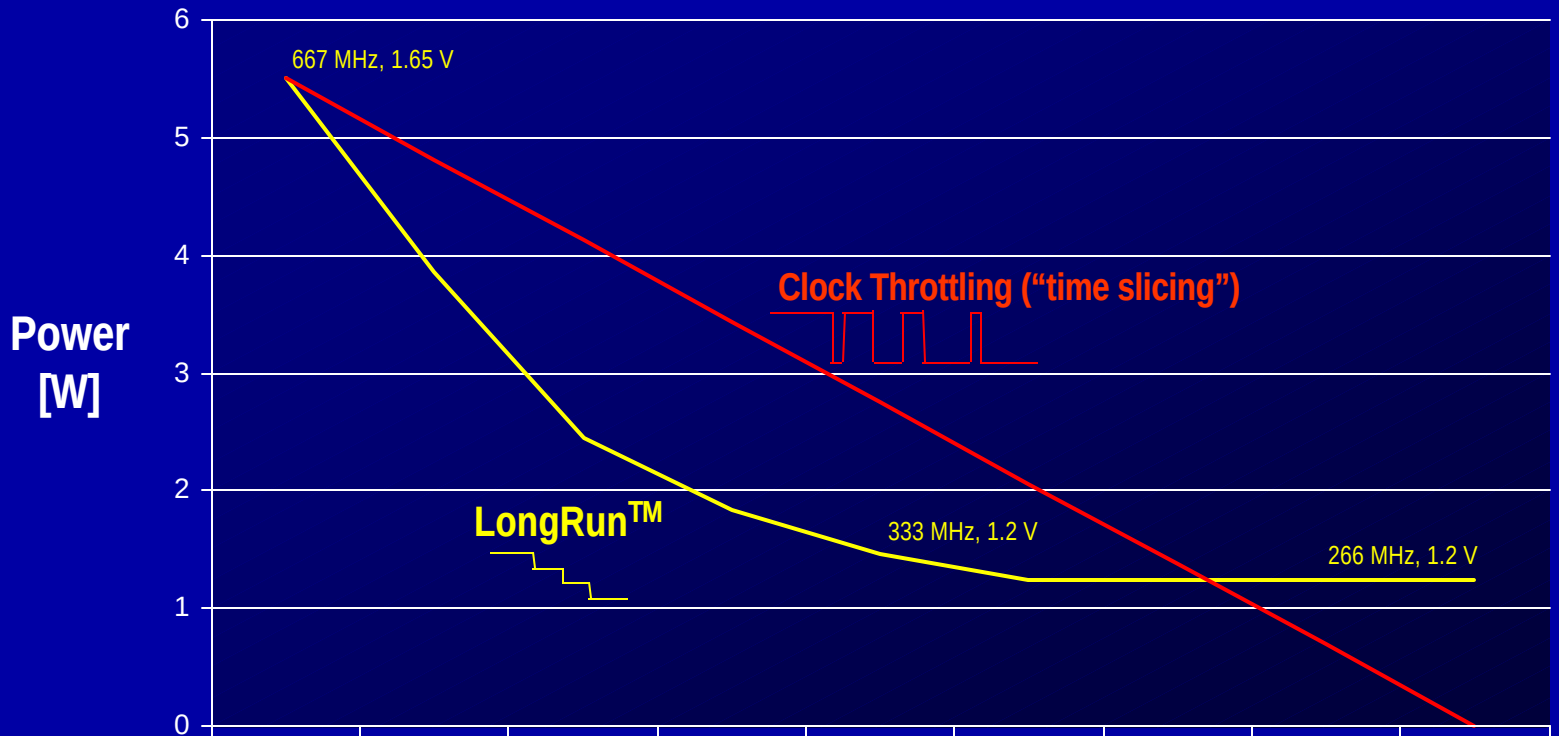
$$Power = c \times v^2 \times f$$

- **Dynamically adapt both frequency and voltage to performance demands**
- **Mechanisms in CPU - fully programmable**
- **Policies in Code Morphing**
  - Adapt f to demand
  - Reduce v proportionally
  - ⇨ Cubic power savings!



	Normal	12.5%	25.0%	37.5%	50.0%	62.5%	75.0%	87.5%
SDR	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.2
DDR	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Core+NB	5.0	3.4	2.1	1.5	1.2	0.9	0.9	0.9

LongRun Adaptive Power Control
vs. Traditional Power Management



	Normal	12.5%	25.0%	37.5%	50.0%	62.5%	75.0%	87.5%	C3
LongRun	5.5	3.9	2.5	1.8	1.5	1.2	1.2	1.2	1.2
C3	5.5	4.8	4.1	3.4	2.8	2.1	1.4	0.7	0.0

Notes

[1] TM5400 pre-production silicon

[2] Power numbers include Northbridge

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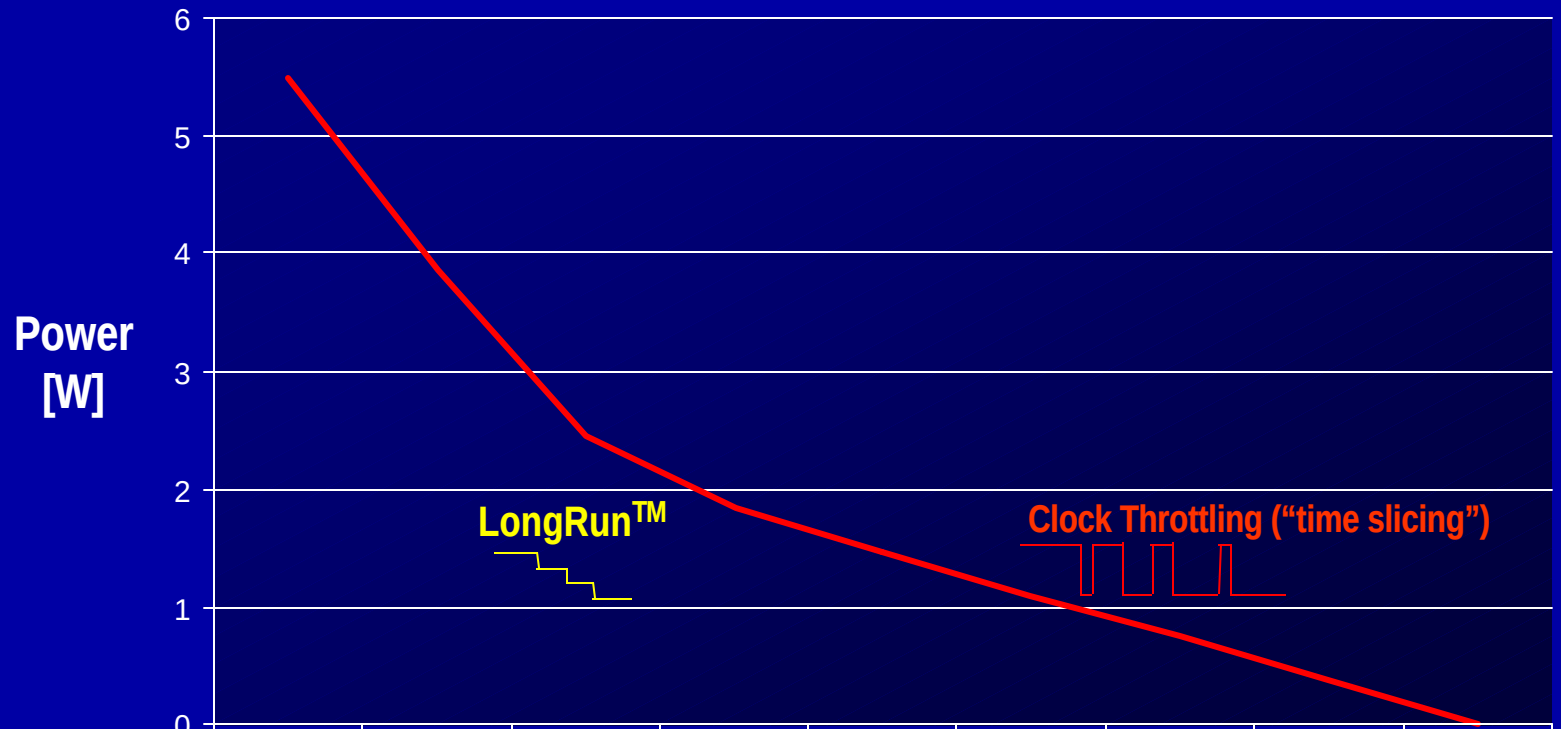
LongRun Adaptive Power Control

Crusoe Power Profile



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TM5400	5.5	3.9	2.5	1.8	1.5	1.1	0.7	0.4	0.0

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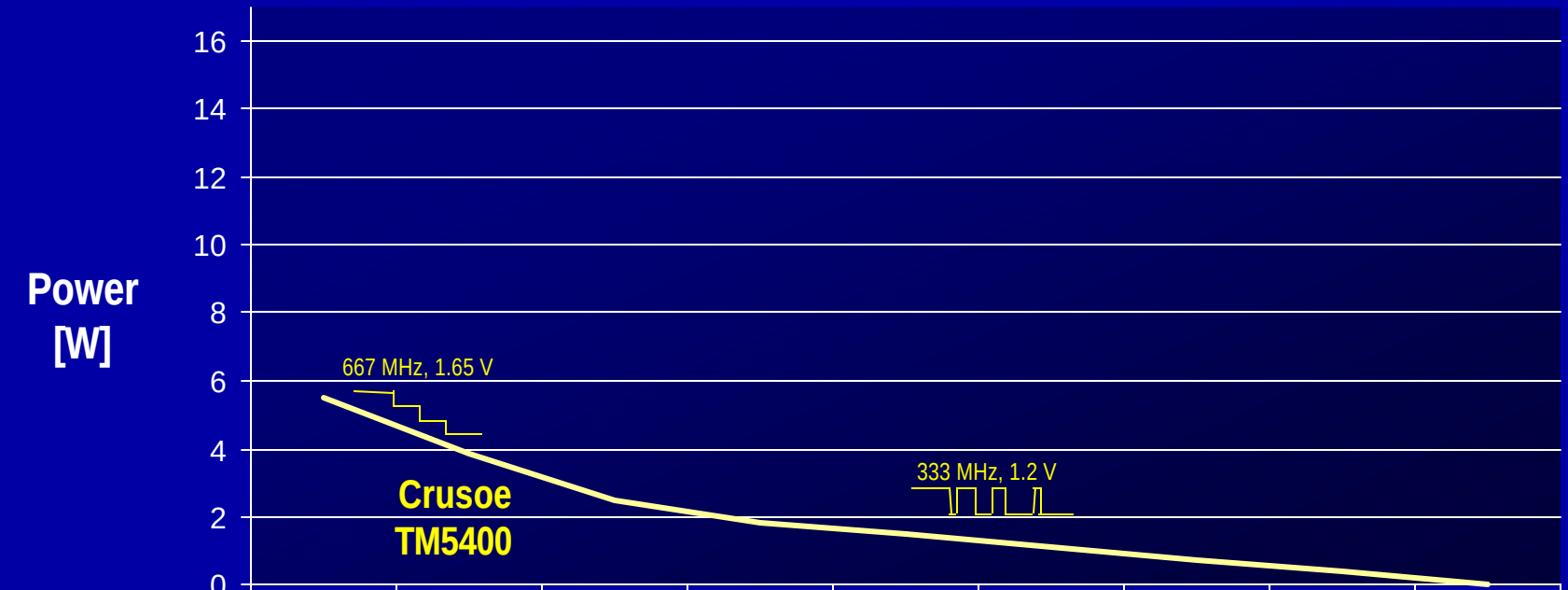
The LongRun Effect
Power Profiles



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The LongRun Effect
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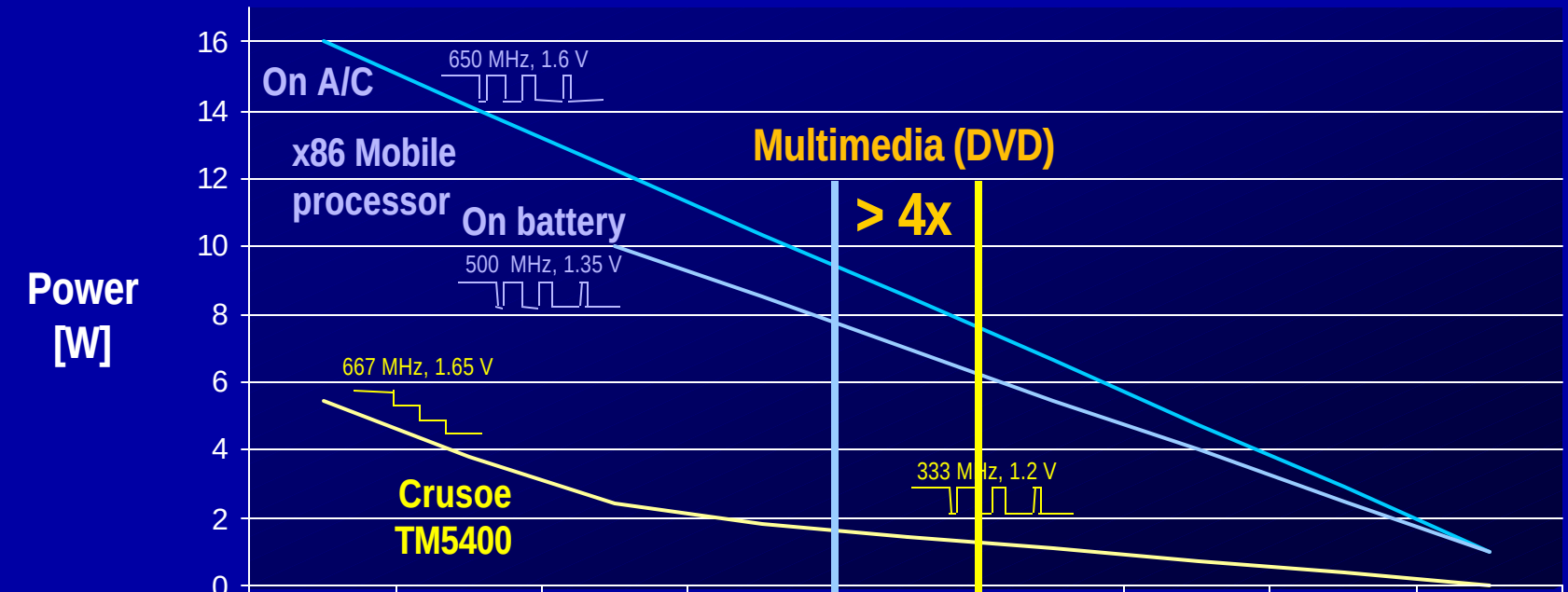

	Normal	12.5%	25.0%	37.5%	50.0%	62.5%	75.0%	87.5%	C3
TM5400+NB	5.5	3.9	2.5	1.8	1.5	1.1	0.7	0.4	0.0
A/C	16.0	14.1	12.3	10.4	8.5	6.6	4.8	2.9	1.0
Battery			10.0	8.5	7.0	5.5	4.0	2.5	1.0

Notes

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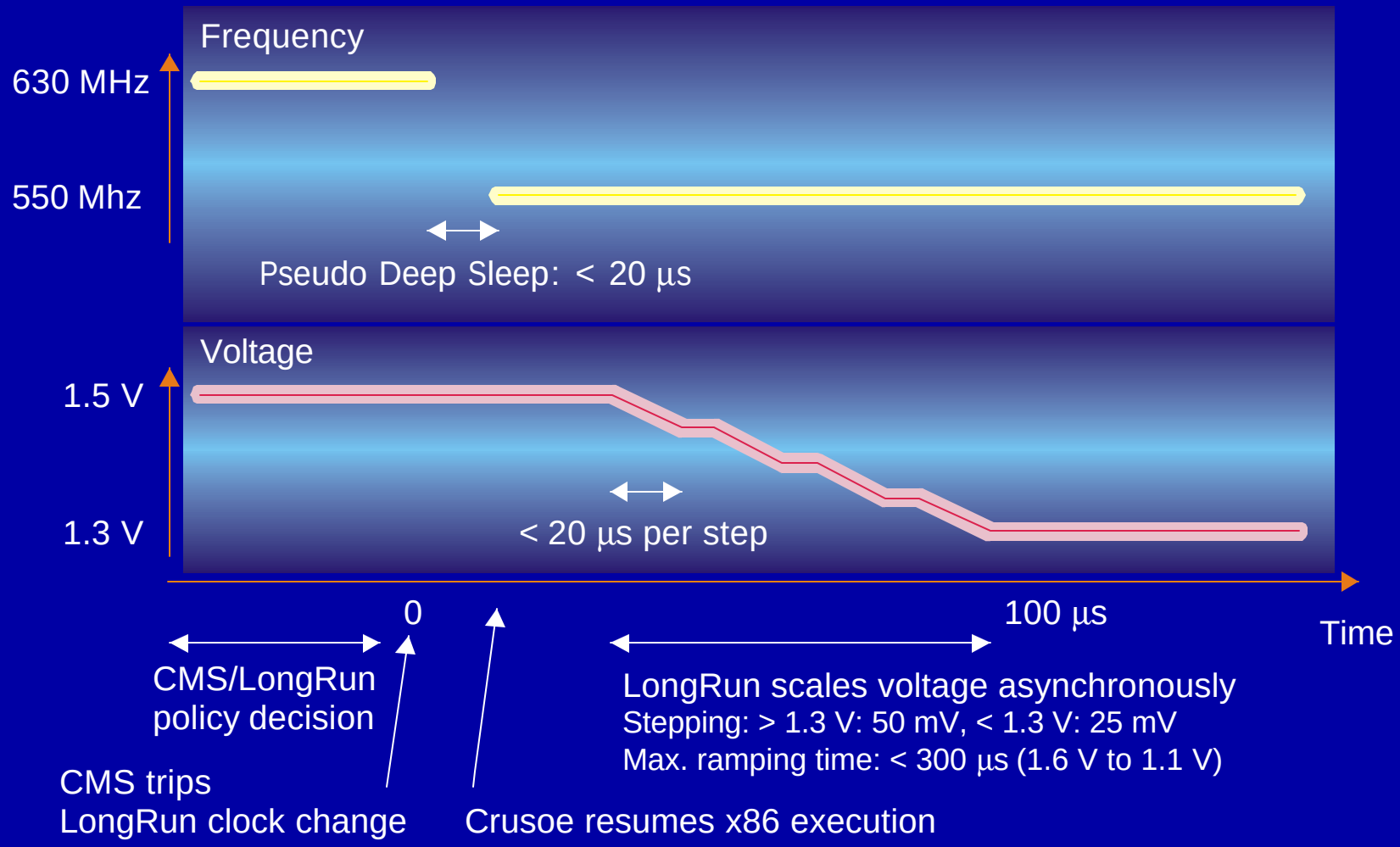
LongRun - How does it all work?
Example: 40% Power Reduction



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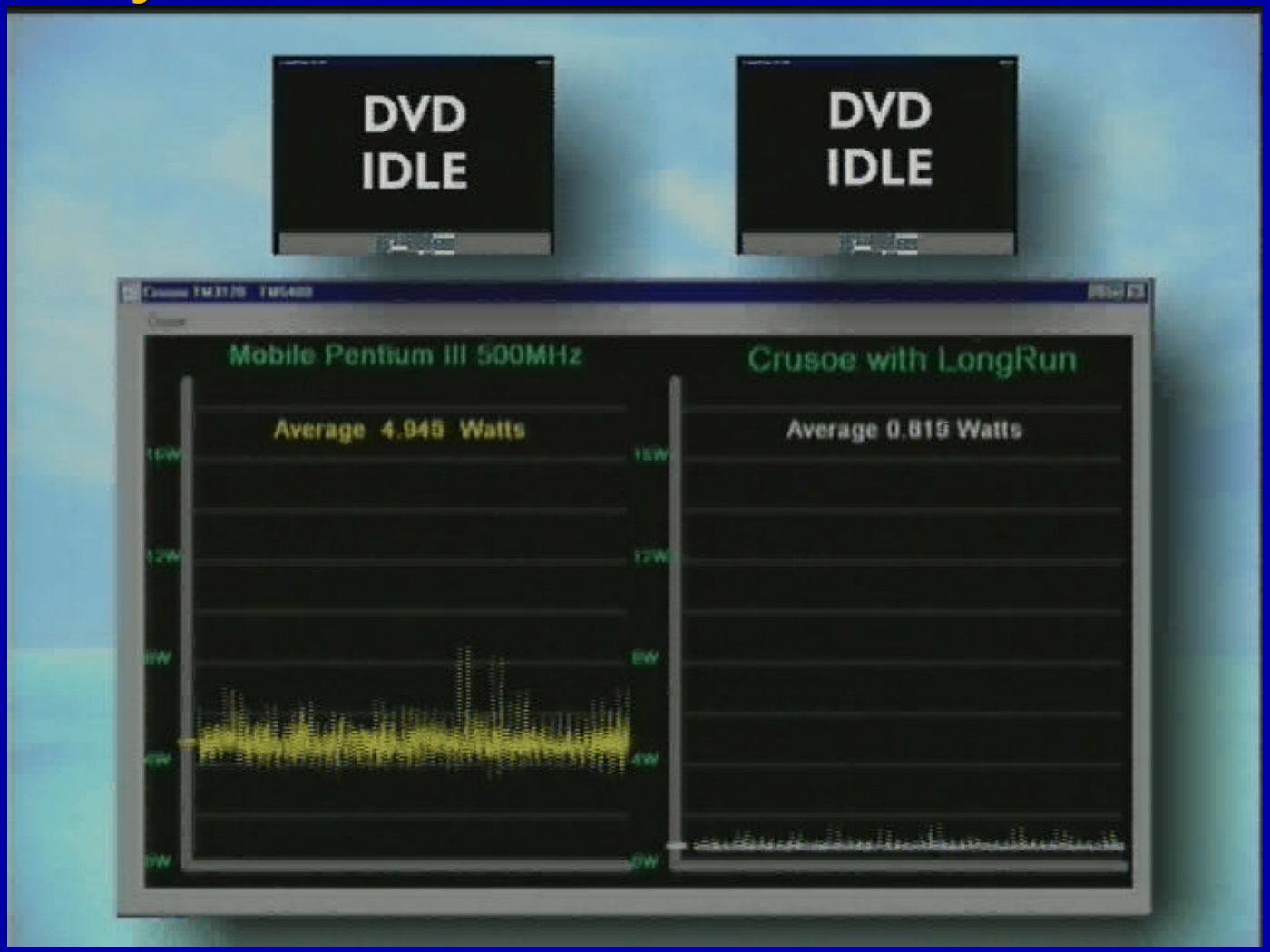
The LongRun Advantage
DVD Playback - Performance on Demand



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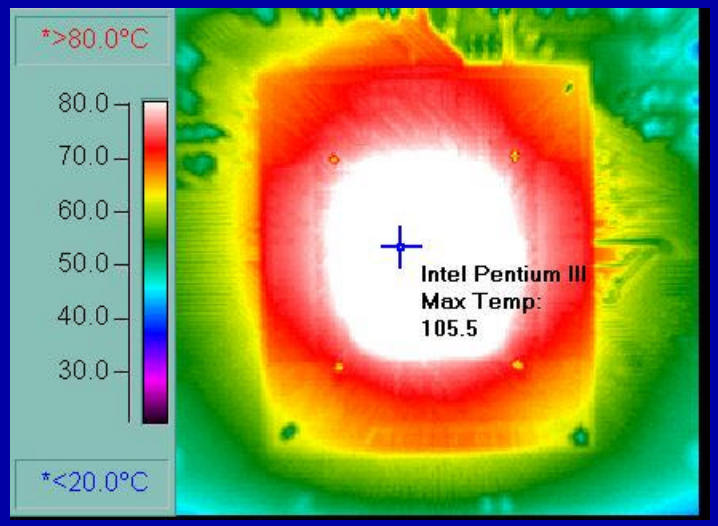
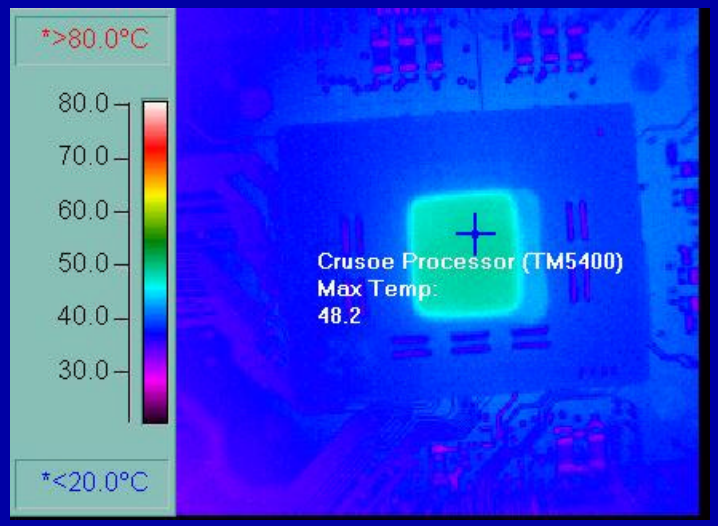
The LongRun Advantage
DVD Playback - Thermal Comparison





Mobile Pentium III® Processor

105.5º C 221.9º F

Active thermal solution required (Fan or overload protection)

Crusoe™ TM5400 Processor with LongRun™

48.2º C 118.8º F

Passive thermal solution (No fan or overload protection)

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Summary
Crusoe Blends the x86 with Low Power

- Crusoe meets the demands of mobile users ("ease of use" and "portability") by delivering significant power savings
- Traditional x86 power management states
  - Normal: 2x - 3x power savings
  - Sleep: 3x - 30x power savings
- LongRun Adaptive Power Control
  - Normal: 2x - 10x power savings