Resource Friendly Platform Requirements for Portable Computers Using Broadband Applications

Kazunori Sugiura
(uhyo@sfc.wide.ad.jp)
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Akimichi Ogawa, Osamu Nakamura, Jun Murai
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Motivations

What?

- Maximizing the resource conservation

When?

using the broadband network applications

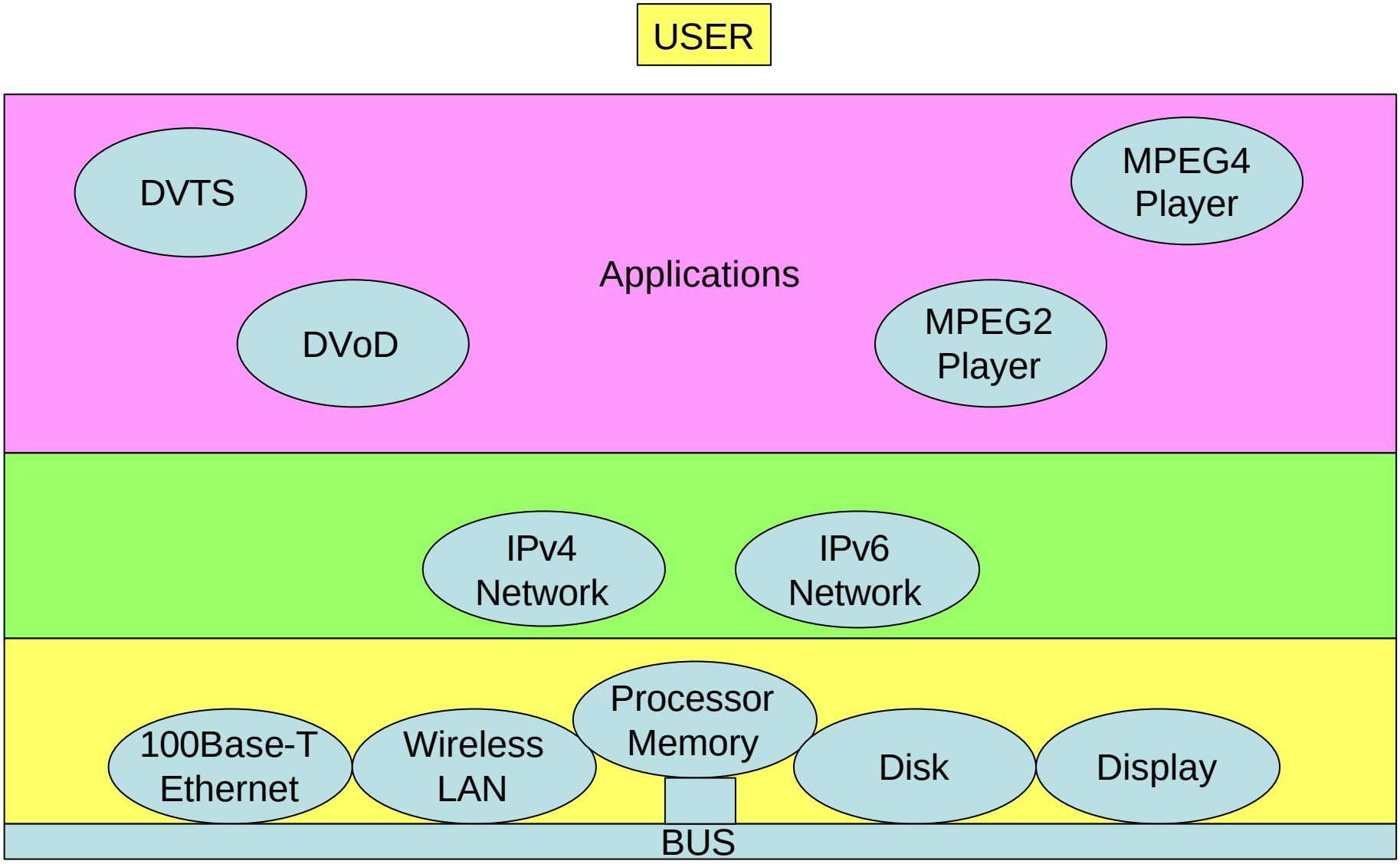
While?

using the portable computers (Note PCs)

in ?

IPv4 and IPv6 networks

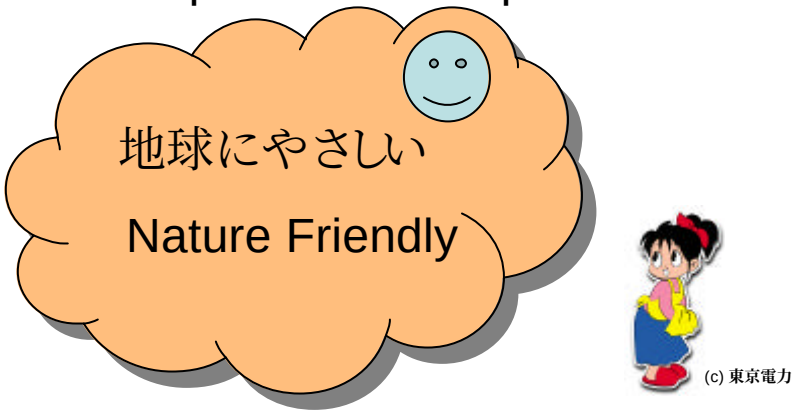
Focuses


USER
DVTS
MPEG4 Player
Applications
DVoD
MPEG2 Player
IPv4 Network
IPv6 Network
Processor Memory
100Base-T Ethernet
Wireless LAN
Disk
Display
BUS

Goals

- Realization of …
  - Economical resource management to broadband network applications

Conserve power consumption

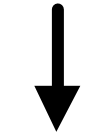


Applying to the IPv6 application environment

IPv6 is a nature friendly environment

Power Conservation

- Power conservation in IPv6 environment
  - Scalability enhancement in IPv6 architecture
  - For example:
    - Consuming 1Watt of electricity per PC.
      - Thinking of how many machines are connected in IPv6?



Popularization of IPv6 network environment

Enhancement in power conservation movement

Construction of Note PCs

- Processors:
  - Traditional Pentium III, Pentium 4, Celeron
  - Mobile Pentium III Pentium 4, Mobile Celeron
  - Transmeta Crusoe
  - Mobile AMD K6
- Memory:
  - SDRAM, DDR-SDRAM
  - 128MB and up
- Networks:
  - Internal 100Base-TX Ethernet
  - Internal 802.11b wireless network
  - Internal Bluetooth network
  - PCMCIA based network connection
    - » 10,100Base-TX Ethernet
    - » 802.11a,11g wireless LAN
  - USB based network connection
    - » USB Ethernet
- Battery operation:
  - Li-ION battery
- IEEE1394 Interface

Considering Broadband Applications using Note PCs

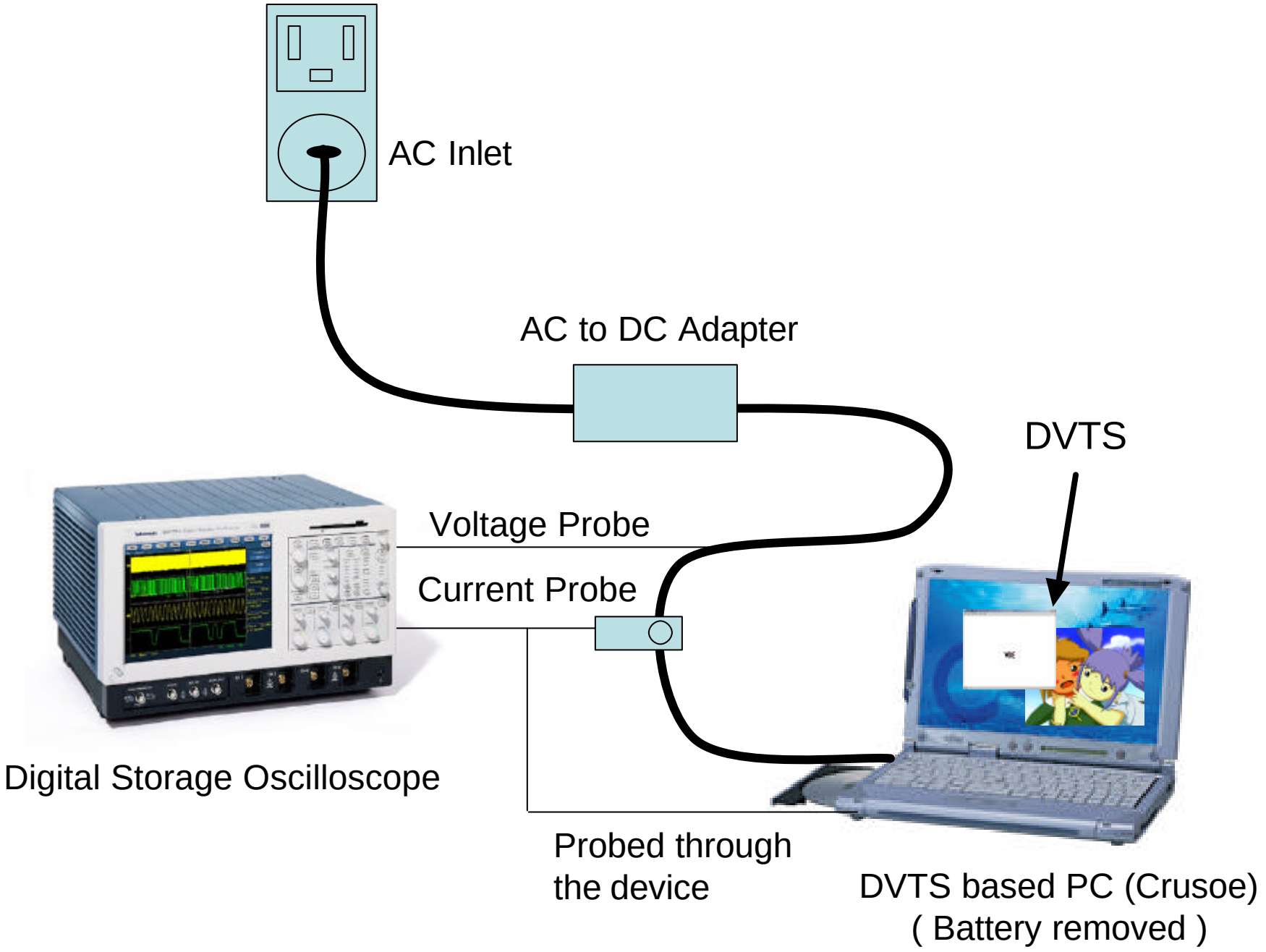
- Lot’s of resources to use
  - Processors
  - Video Chips
  - Network Interface
    - Ethernet Interface
    - Wireless Networks
  - Disk Storage
    - Downloading
  - IEEE1394 Interface
    - Using Consumer DA/AD Media Converter (Camera)

Measurement of Power Consumption

Measuring Resource Consumption

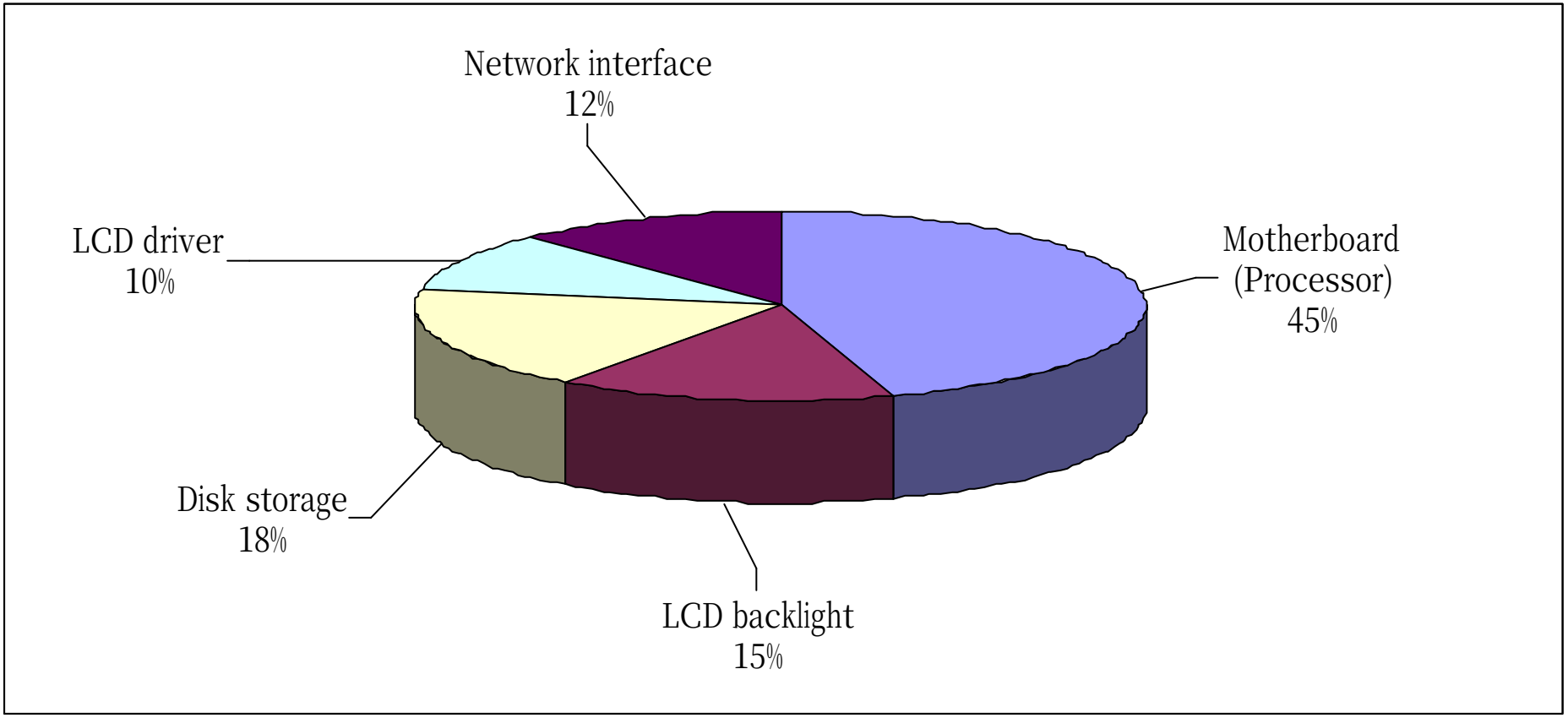
- Resource consumption measurement based upon…
  - Power Consumption
  - Active measurement
    - Realistic measurement with oscilloscope
    - Accurate measurements including
      - DC-DC converter internal losses
  - Passive measurement
    - Information given by devices
      - Power consumption ratio
      - Power consumption ratio by battery

Active measurement probes higher measurements compared to passive measurement


AC Inlet
AC to DC Adapter
DVTS
Voltage Probe
Current Probe
Digital Storage Oscilloscope
Probed through
the device
DVTS based PC (Crusoe)
(Battery removed)

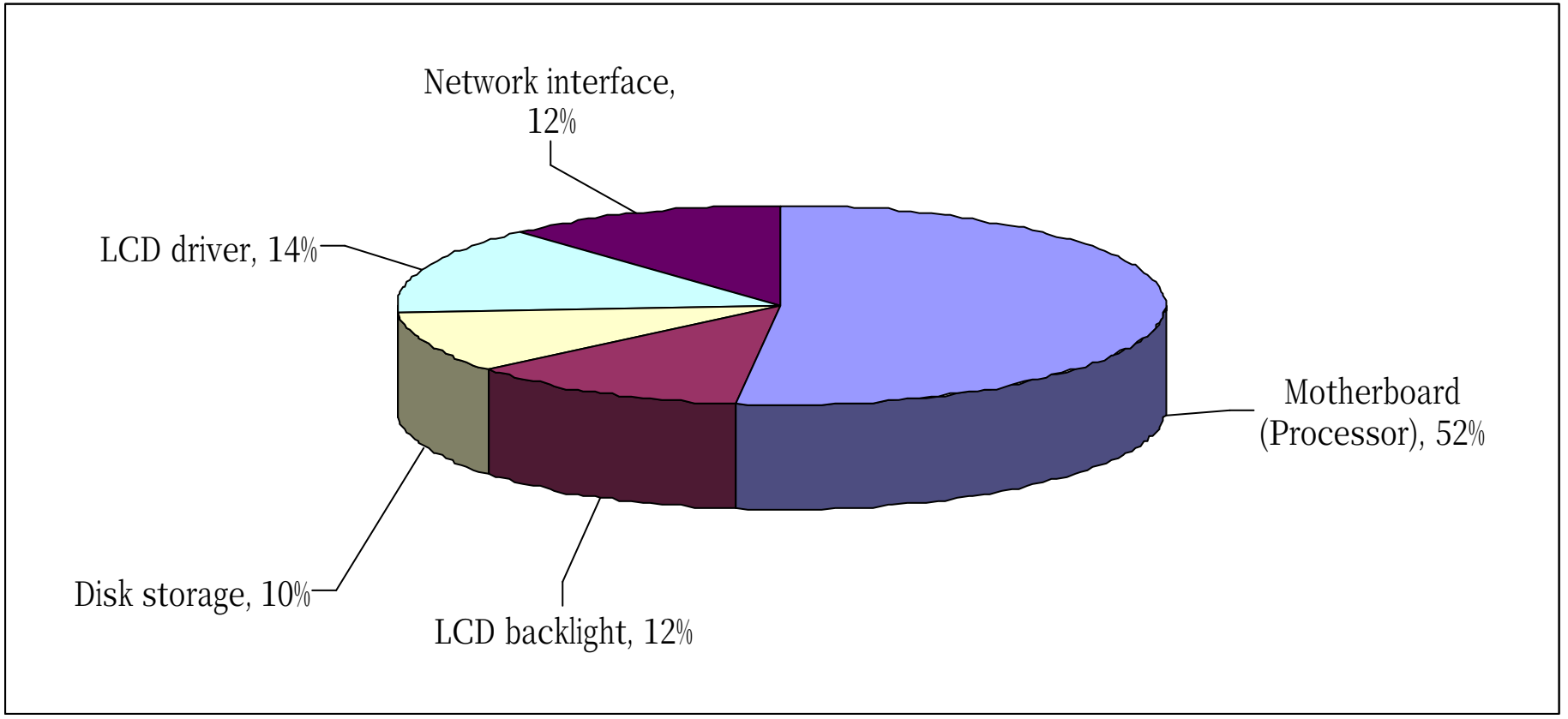
Average Power Consumption of the Note PC

Running Application: DVTS (dvrecv)
FreeBSD 4 (IPv6)



Average Power Consumption of Note PC (2)

Running Application: DVTS (dvrecv)
Windows XP (IPv6)
(DirectShow Viewer)



Difference Between IPv4 and IPv6

Operating System	Base Protocol	Total Power Consumption (W)	Network Interface Power (W)	Percentage	
FreeBSD + KAME	**IPv4**	**21.10**	**2.69**	**12.75**	105.4%
	IPv6	**22.25**	**2.72**	**12.25**	
Windows XP	**IPv4**	**25.50**	**2.73**	**10.70**	104.1%
	IPv6	**26.55**	**2.85**	**10.75**	
Linux + Usagi	**IPv4**	**22.25**	**2.69**	**12.10**	105.6%
	IPv6	**23.50**	**2.71**	**11.55**	

Machine: ThinkPad T23 (Mobile Pentium III 1GHz) Memory: 512MB
(FULL Speed , No Power Conservation)
Running Application: DVTS (dvrecv)

Power Consumption in IPv6 (Summary)

- Tends to use more power on
  - Processors and memory (Average 4% +)
- Slight power consumption raise in
  - Network Interface (100Base-T Ethernet)
- Operating System Comparison:
  - Power hungry Operating System of the Year

WINDOWS XP

- Reasons:
  - Direct show Video playback (Uses Processor and Video)
  - Complex OS Structure
- Compared to FreeBSD, Windows XP Consumes 11.9% more energy

RESULTS: Using Windows XP is not Nature Friendly!

Consideration of Power Conservation

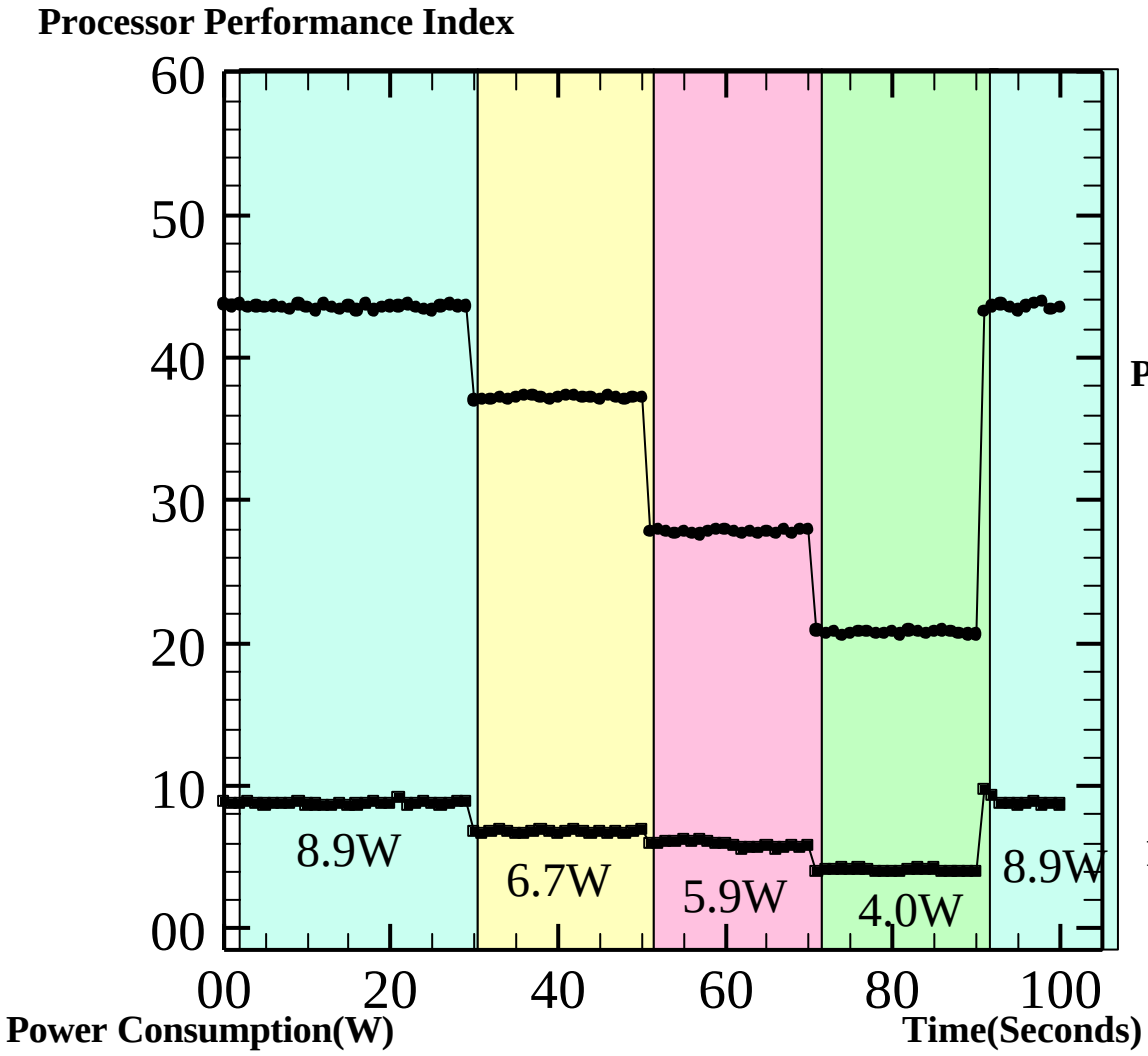
Running Application in Note PCs

- Autonomous power management functions
  - Such as:
    - Processor power management
      - » Dynamic Voltage Scaling (DVS)
    - Bus power management
    - Interface power management
      - » TDM Algorithms on wireless networks

Processor Frequency, Utilization, and Voltage

Frequency (MHz)	Voltage (v)	Throttle (%)
300	1.20	0
366	1.23	33
433	1.40	66
533	1.55	100

Power Conservation based on Dynamic Voltage Scaling



Machine:

Fujitsu LOOX
533MHz Crusoe 5600
OS: FreeBSD Crunch
Base: 4.3-Release

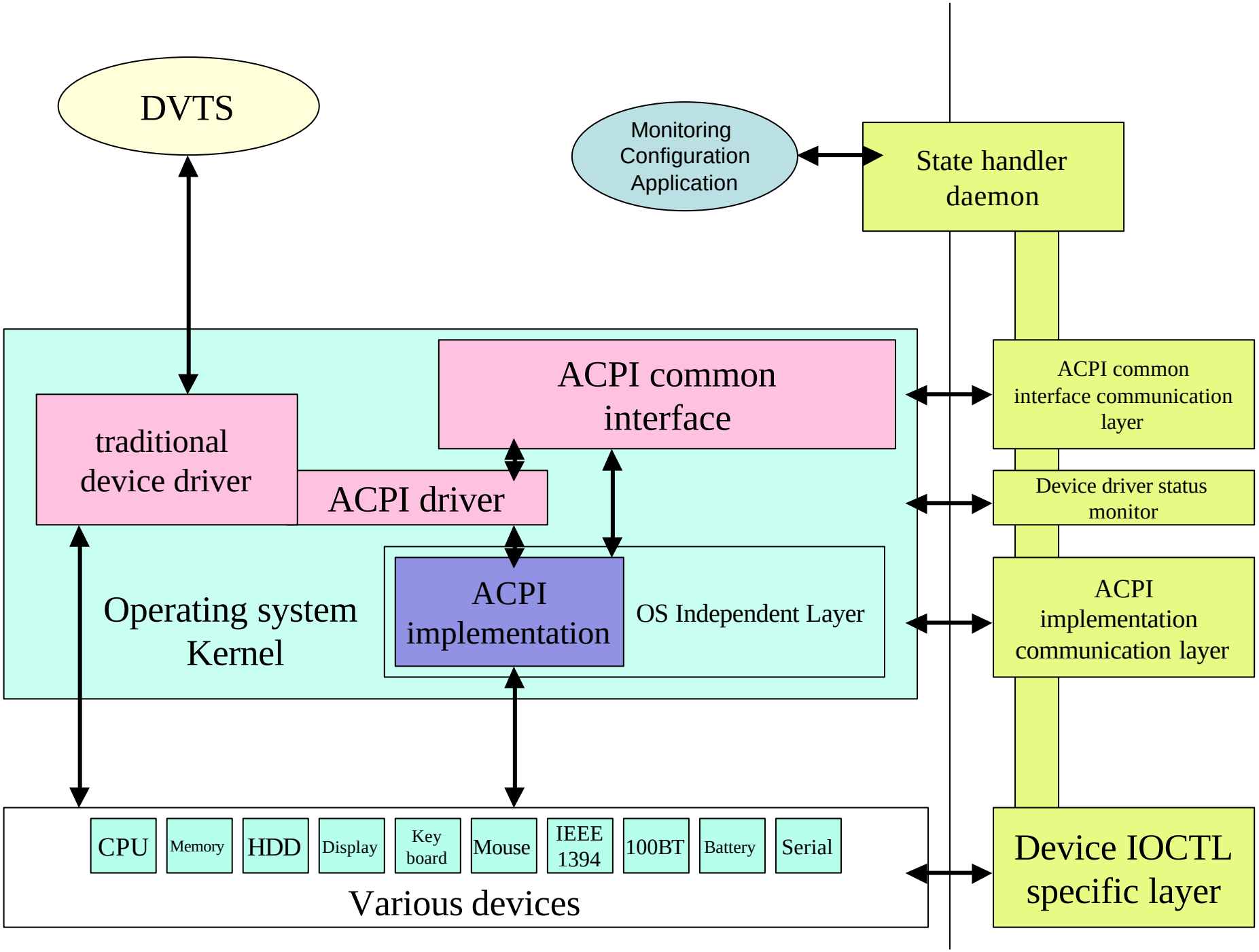
Arbitrary Resource Management

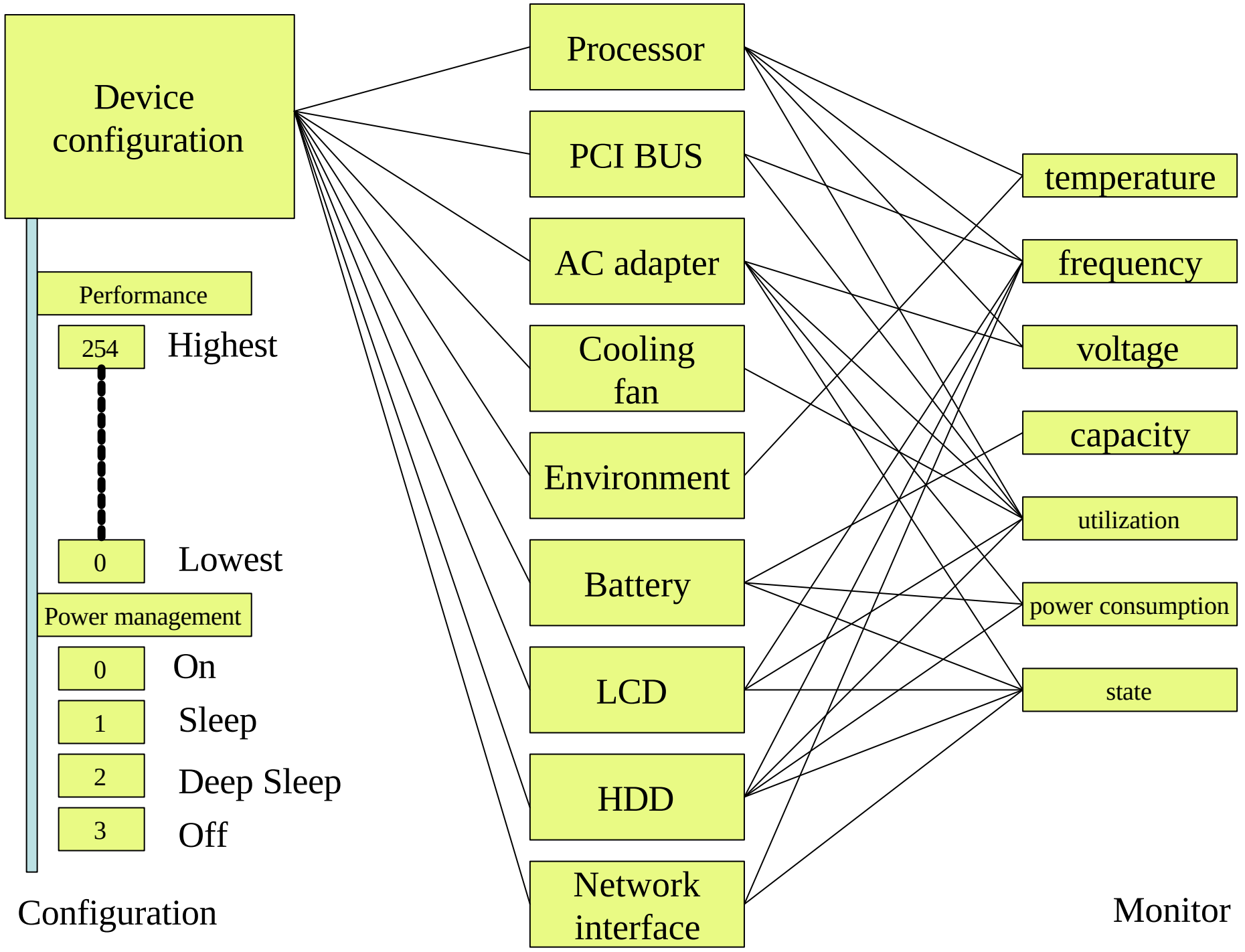
- To maximize the usage in battery operation:
  - Portable computers automatically adjusts:
    - Processor clocks
    - Bus clock
    - Processor voltage
    - By the hardware monitoring method based on:
      - Utilization
      - Power consumption limitation (battery, DC converter)
      - Temperature
  - SOME WITHOUT ANY NOTIFICATION!!!

→ Disabling the feature to minimize the packet losses

Monitoring and Configuration Mechanism for Devices

- Monitoring and configuration mechanism
  - Device environment
- ACPI
  - Advanced Configuration and Power Interface
- State Handler
  - Monitors and configures device by accessing ACPI


DVTS
Monitoring Configuration Application
State handler daemon
ACPI common interface
traditional device driver
ACPI driver
ACPI implementation
OS Independent Layer
Operating system Kernel
ACPI common interface communication layer
Device driver status monitor
ACPI implementation communication layer
CPU
Memory
HDD
Display
Key board
Mouse
IEEE 1394
100BT
Battery
Serial
Various devices
Device IOCTL specific layer


Device configuration
Performance
254
Highest
0
Lowest
Power management
0
On
1
Sleep
2
Deep Sleep
3
Off
Configuration
Processor
PCI BUS
AC adapter
Cooling fan
Environment
Battery
LCD
HDD
Network interface
temperature
frequency
voltage
capacity
utilization
power consumption
state
Monitor

Sample Application

% getacpiinfo -t ACPI_BATTERY all

---------- Battery Status ----------	
Manufacture:	**Panasonic**
Manufacture Date:	**2001,8,8**
Production Date:	**2001,9**
Serial No:	**10091**
OEM Optional Field 1:	**1Z43TS3108**
Battery Name:	**FMLBP102**
Device:	**Li-ION**
Battery Amount(Wh):	**38.20**
Battery Voltage(V):	**10.80**
---------- Operating Status ----------	
State:	**Charging**
Left(%):	**21**
Time left Charged(min):	**95**
Amount Left(Wh):	**8.23**
Full Amount(Wh):	**37.21**
Current(A):	**2.68**
Voltage(V):	**11.80**
Power(W):	**31.62**
Temp(c):	**19**
Charge Cycle:	**34**

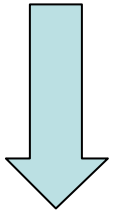
% getacpiinfo -t ACPI_PROCESSOR mode

Processor_type:	**LongRun**
Current Mode:	**Performance Mode**
Clock(MHz)	**300**
Voltage(V):	**1.20**
Throttle(%):	**0**

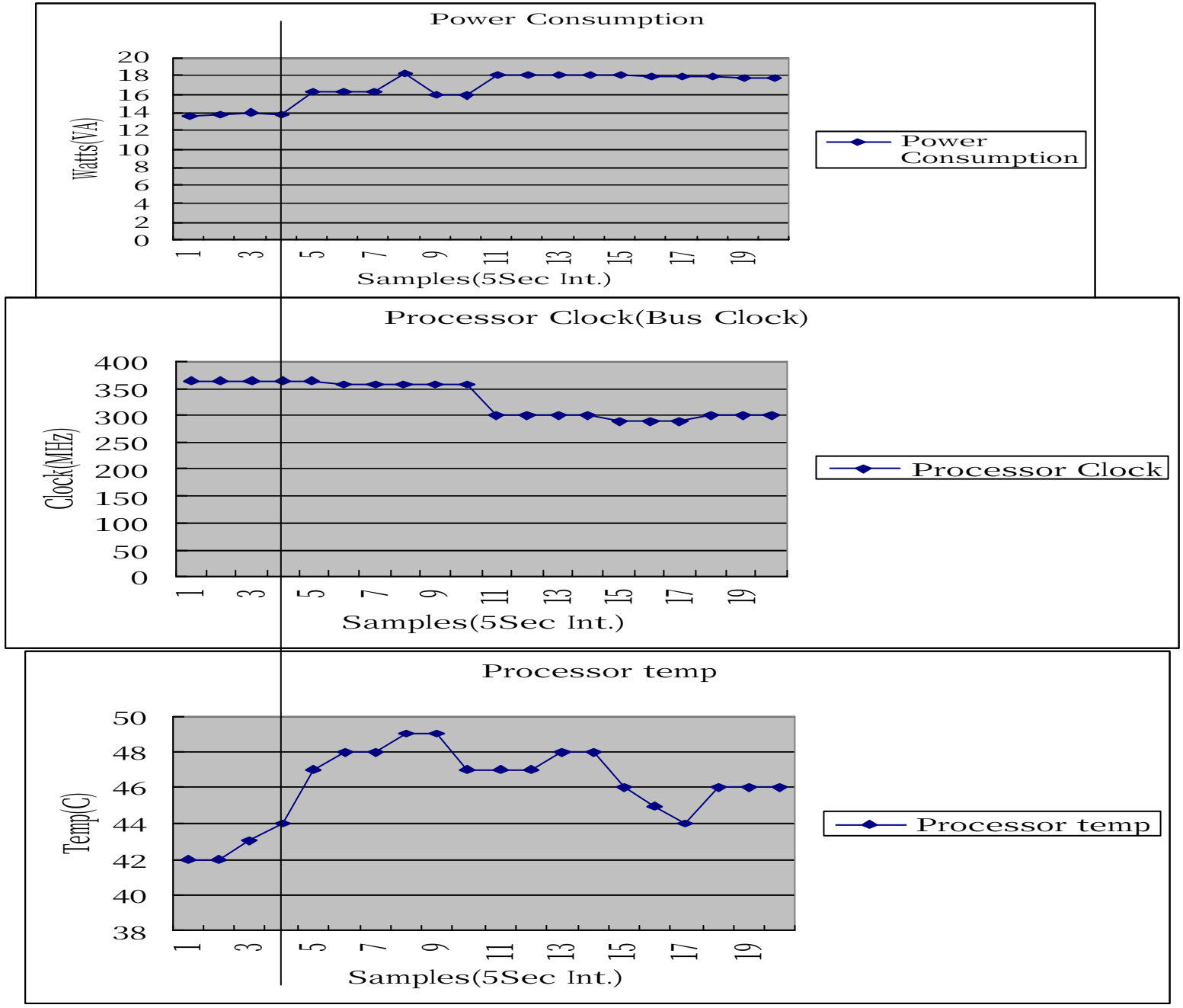
Sample of
Arbitrary Management

Measurement Sample

- Running Note PCs in high utilization
  - Full specification
  - Full speed



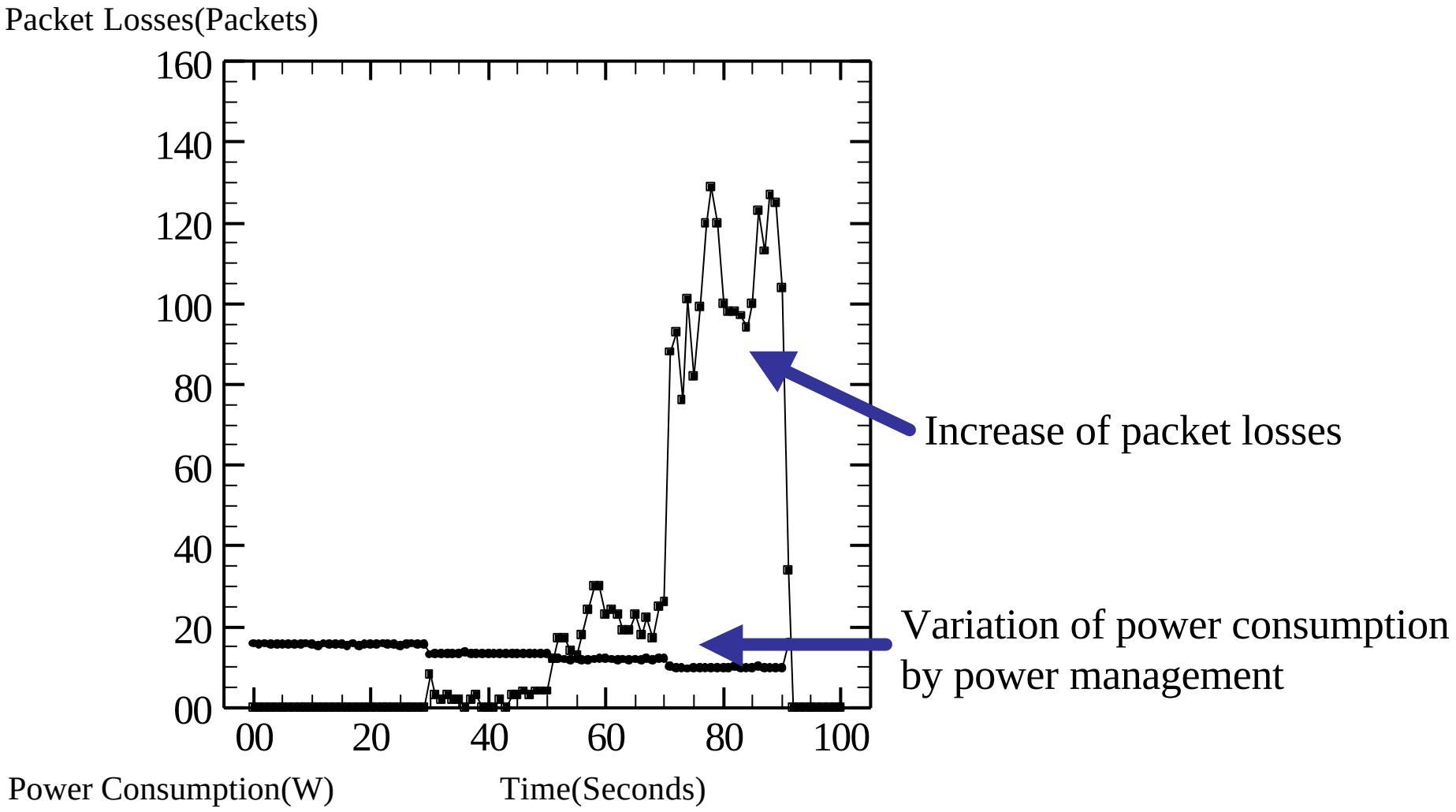
Some Note PCs are not applicable to run at high utilization for long period


Power Consumption
Watts(VA)
20
18
16
14
12
10
8
6
4
2
0
1
3
5
7
9
11
13
15
17
19
Samples(5Sec Int.)
Power Consumption
Processor Clock(Bus Clock)
Clock(MHz)
400
350
300
250
200
150
100
50
0
Samples(5Sec Int.)
Processor Clock
Processor temp
Temp(C)
50
48
46
44
42
40
38
Samples(5Sec Int.)
Processor temp

Using DVTS in High Utilization

- Running DVTS under…
  - Dynamic Voltage Scaling
  - High utilization
  - IPv6 environment

Packet Losses Created by Power Management



Solutions

- Device configuration mechanism to
  - Adapt optimized device configuration in
    - Power managed mode
    - Use optimal power in a deadline
  - Modification of DVTS
    - Dynamically configure the device mode

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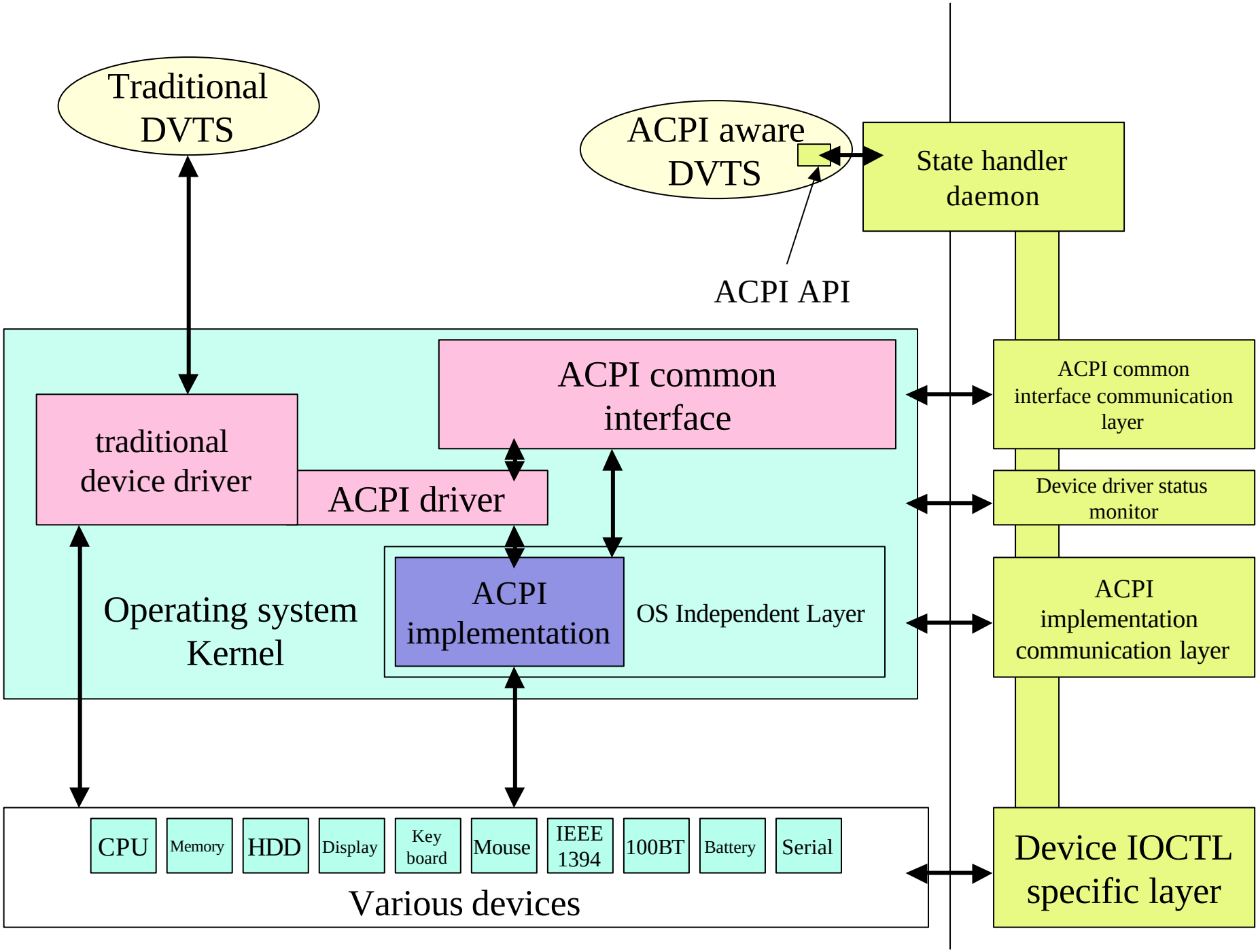
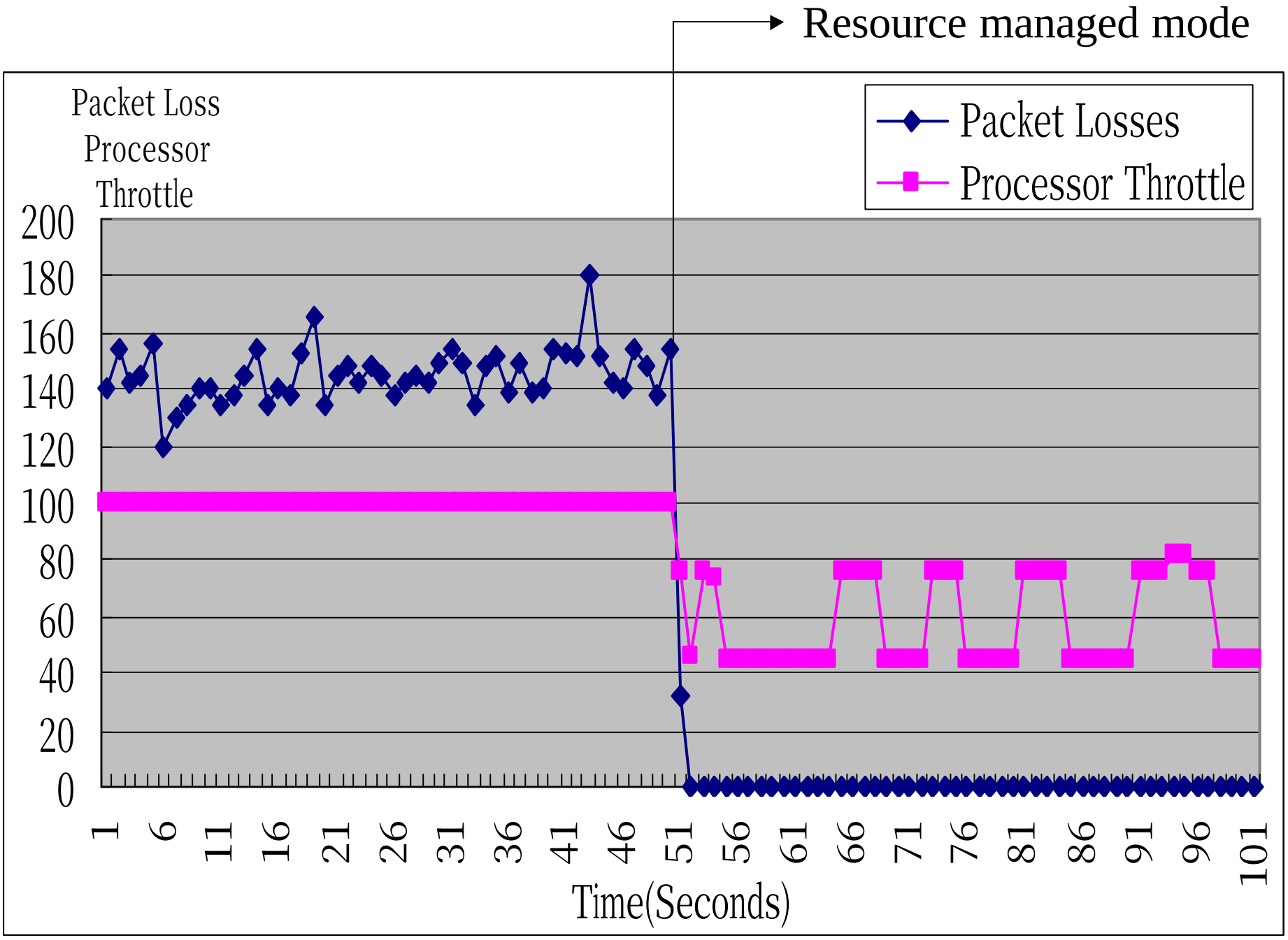
Collaboration with state handler daemon


Traditional DVTS
ACPI aware DVTS
State handler daemon
ACPI API
ACPI common interface
traditional device driver
ACPI driver
ACPI implementation
OS Independent Layer
Operating system Kernel
ACPI common interface communication layer
Device driver status monitor
ACPI implementation communication layer
CPU
Memory
HDD
Display
Key board
Mouse
IEEE 1394
100BT
Battery
Serial
Various devices
Device IOCTL specific layer

DVTS Device Optimization

- Processor throttle indicator and configuration
  - Dynamic processor and bus clock control
    - To meet the 16msec deadline (DV packet deadline)
    - Adjusting throttle level of CPU Utilization to next DVS steps.
  - Interrupt aggregation of Ethernet interface
    - Aggregate interrupt for packet receive
      - » Maximum buffer size = RXIO buf in controller
      - » Before it reaches the 16msec interval


Resource managed mode
Packet Loss
Processor
Throttle
Packet Losses
Processor Throttle
200
180
160
140
120
100
80
60
40
20
0
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86
91
96
101
Time(Seconds)

Optimizing wireless transmission

- Optimization of 802.11b transmission of DVTS(1/10 frame rate) for 1 hour
  - Sending Constant Bit rate transfer (CBQ)

VS

  - Sending burst traffic based on 160uS (1/100) period
    - 802.11b power managed mode in Fixed idle algorithm (10us)

Network	Power Consumption	Packet Loss
CBR	19.86Wh	3%
Burst	18.20Wh	8%

9.1%

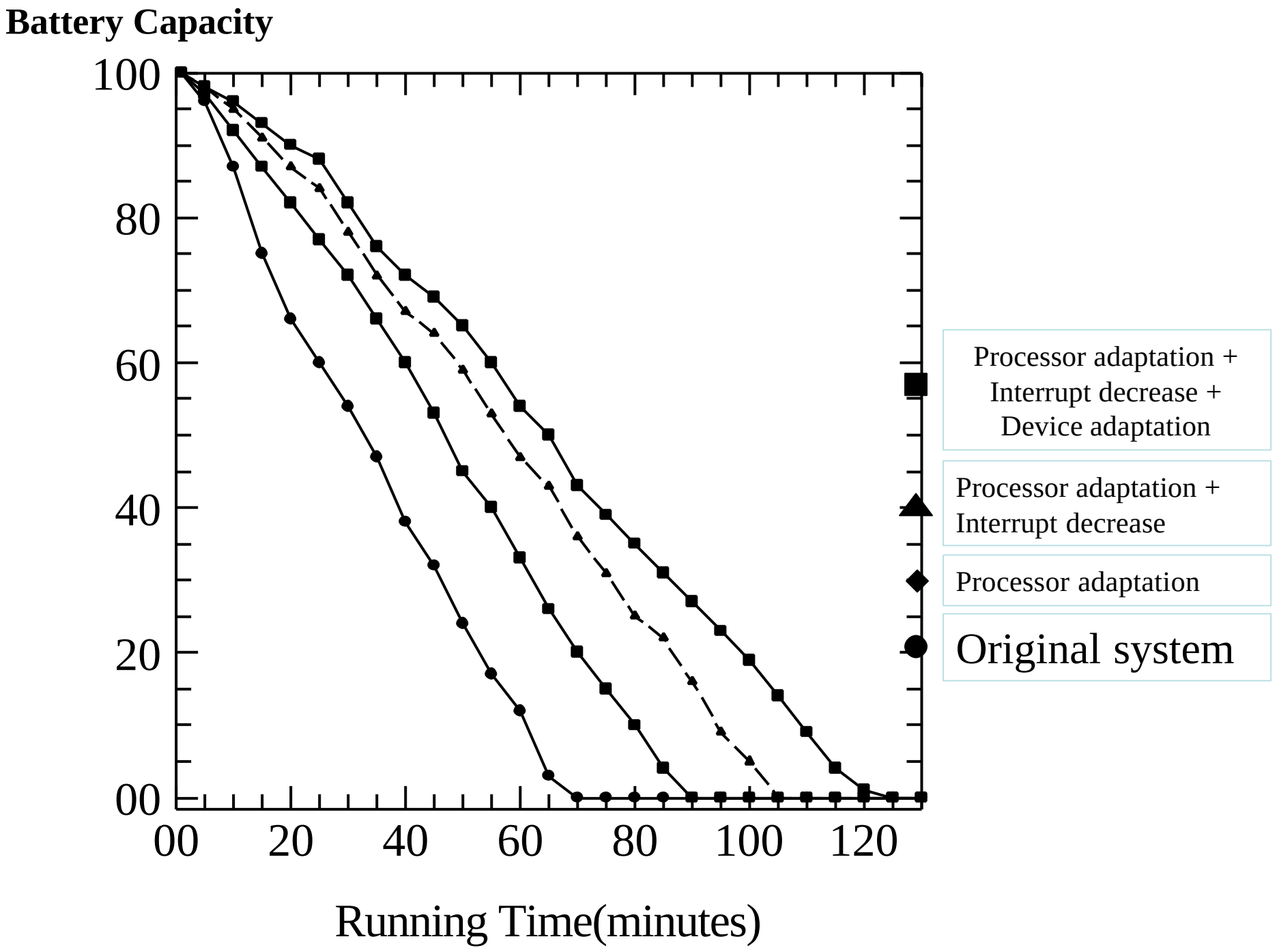
Power Conservation

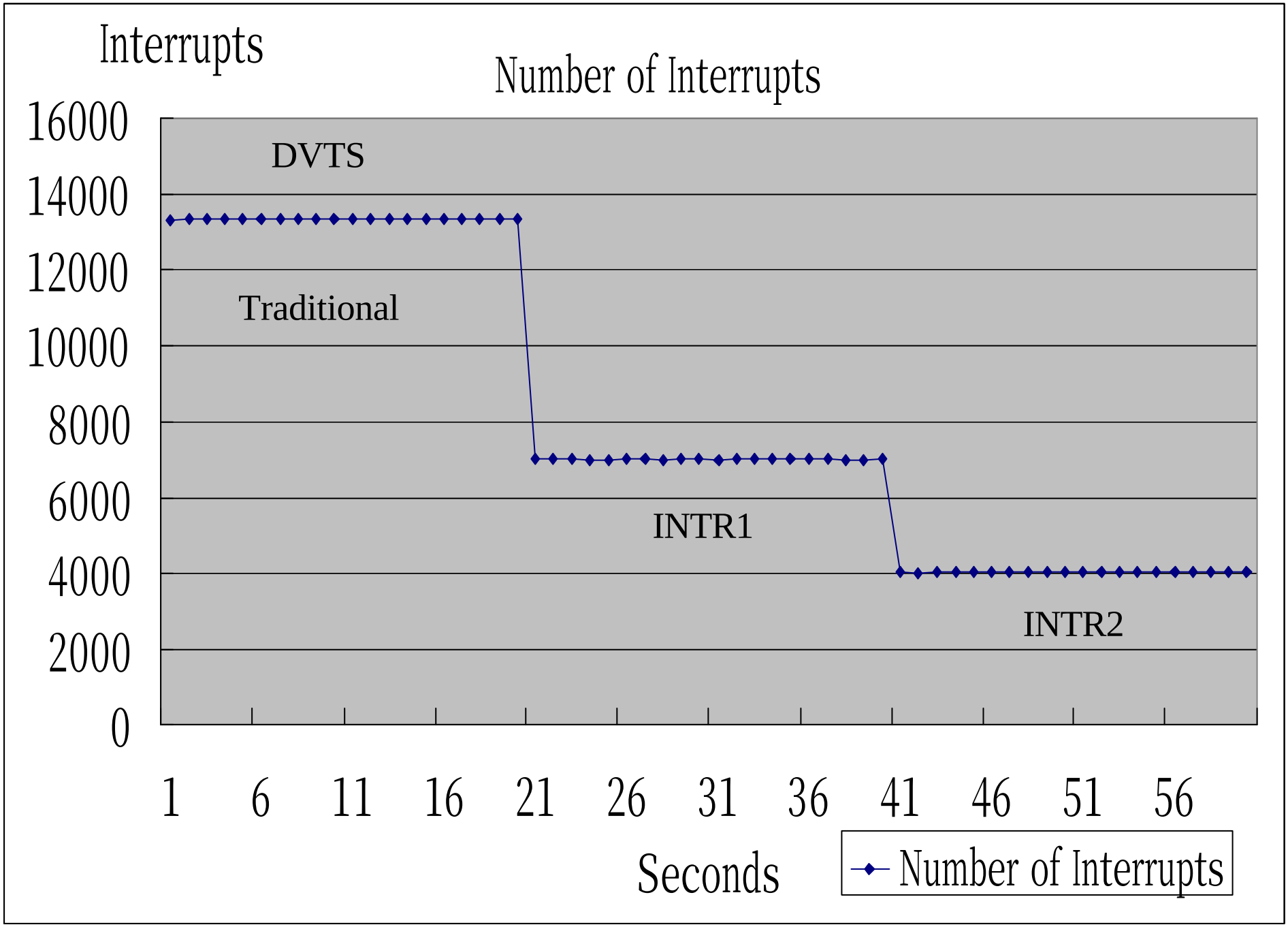
Condition: No Packet losses, DV Packet Deadline timing >= 16ms
Tests: 1 Hour

Operating System	Base Protocol	Power Consumption (Wh)	Conservation Mode (Wh)	Percentage
FreeBSD + KAME	**IPv4**	**21.10**	**17.60**	**83.84**
	IPv6	**22.25**	**18.00**	**80.90**

Machine: ThinkPad T23 (Mobile Pentium III 1GHz) Memory: 512MB
(FULL Speed , No Power Conservation)
Running Application: DVTS (dvrecv)

Demo


Battery Capacity
100
80
60
40
20
00
00
20
40
60
80
100
120
Running Time(minutes)
Processor adaptation + Interrupt decrease + Device adaptation
Processor adaptation + Interrupt decrease
Processor adaptation
Original system


Interrupts
Number of Interrupts
16000
14000
12000
10000
8000
6000
4000
2000
0
DVTS
Traditional
INTR1
INTR2
1
6
11
16
21
26
31
36
41
46
51
56
Seconds
Number of Interrupts

Contribution to the IPv6 Development

- Unique roadmaps considering power consumption based resource management over IPv6 networks
- Goals to implement IPv6 in less power consumption compared to legacy IPv4
- Benchmark schemes for IPv6 platforms depending on power consumption

More people using IPv6

More power conservation!!

Future Works

- Standard benchmark scheme
  - Power consumption
  - Resource utilization
  - Overall performance to consumption index
- Realization of…
  - More applicable interface to resource configuration
  - Technique to reduce power consumption
    - IPv6 Specific reduction design
      - » Optimization based on IPv6?

Conclusions

- Methods to conserve energy:
  - In network environment (IPv6 Networks)
  - Based on resource handling
    - Processor
    - Network interface
    - Disk Drive
  - Measurement scheme

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