Application Characterization for Wireless Network Power Management

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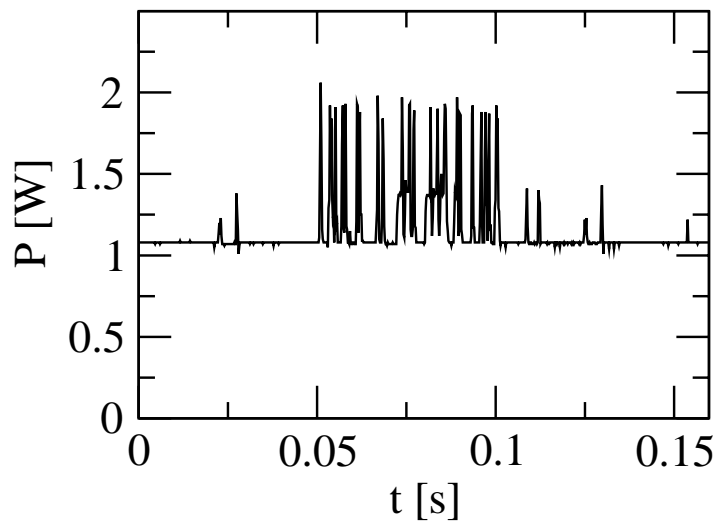
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Outline

- Characteristics of wireless network interfaces

- IEEE 802.11 power management

- Effects on application performance

- Application-specific power management

- Identification of application profiles

- Evaluation

- Conclusion

Characteristics of Wireless NICs
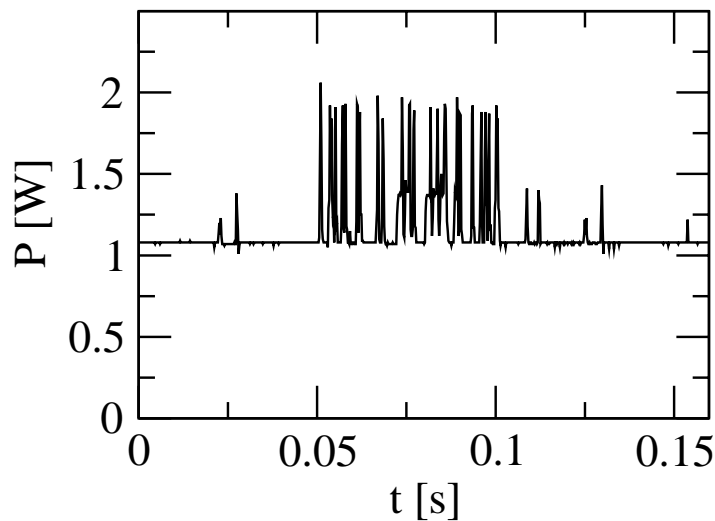
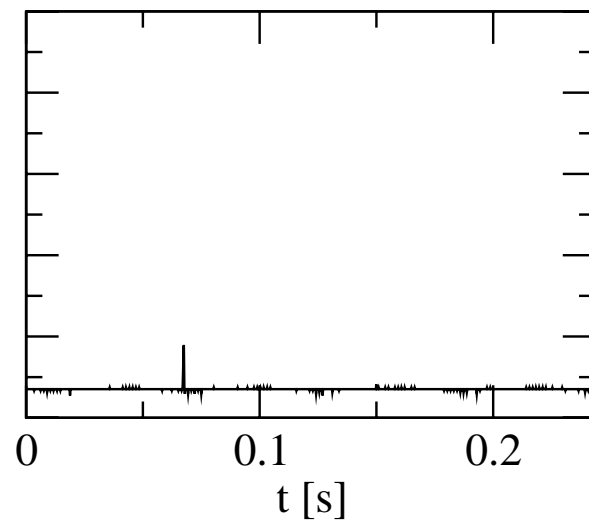- High power consumption in idle mode (> 1W)

power consumption in idle mode

Characteristics of Wireless NICs

- High power consumption in idle mode (> 1W)
- Sleep mode with low power consumption (180mW)
  - ⇨ but: receiving of packets not possible!

power consumption in idle mode
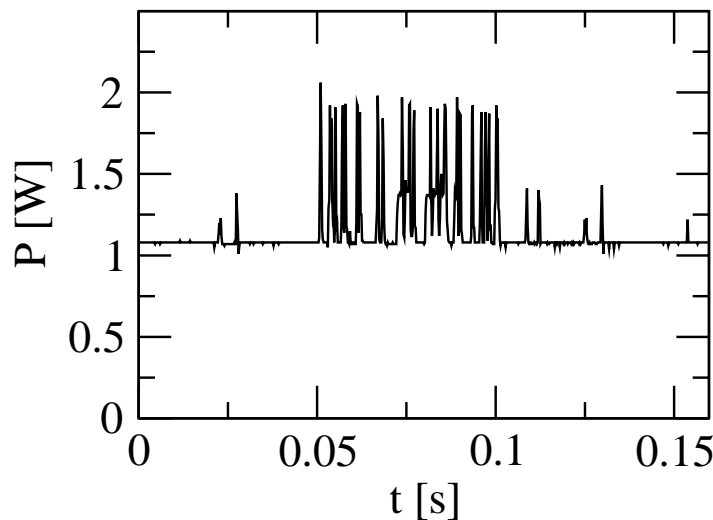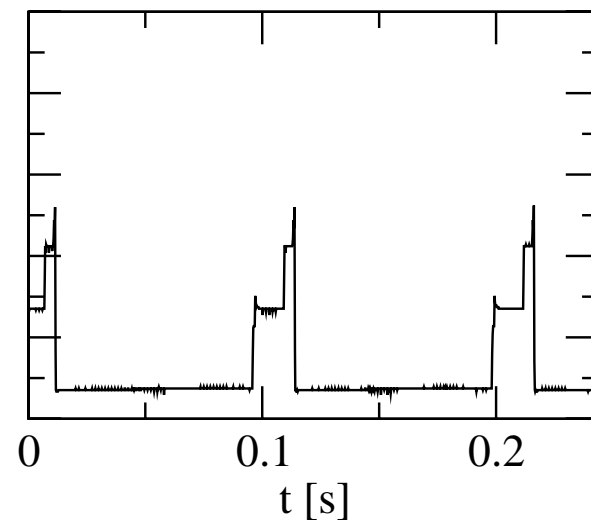

sleep mode

Characteristics of Wireless NICs

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- **Sleep mode with low power consumption (180mW)**
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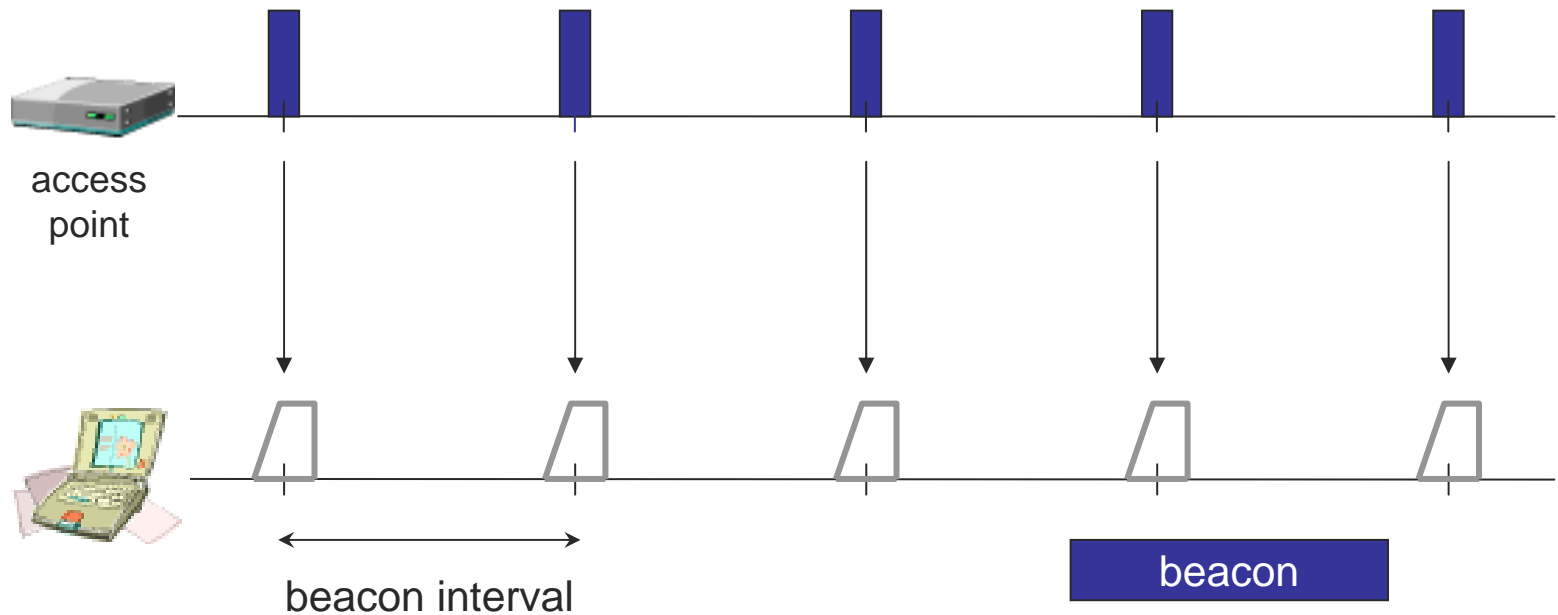 - ⇨ periodic synchronizations with the access point: beacons

power consumption in idle mode

power saving mode

IEEE 802.11 Power Saving Mode

access point

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beacon interval

beacon

IEEE 802.11 Power Saving Mode

access point

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beacon interval

| beacon |
| message |

access point

beacon interval

| beacon |
| message |
| poll |

IEEE 802.11 Power Saving Mode

access point

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beacon interval

| beacon |
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access point

delay
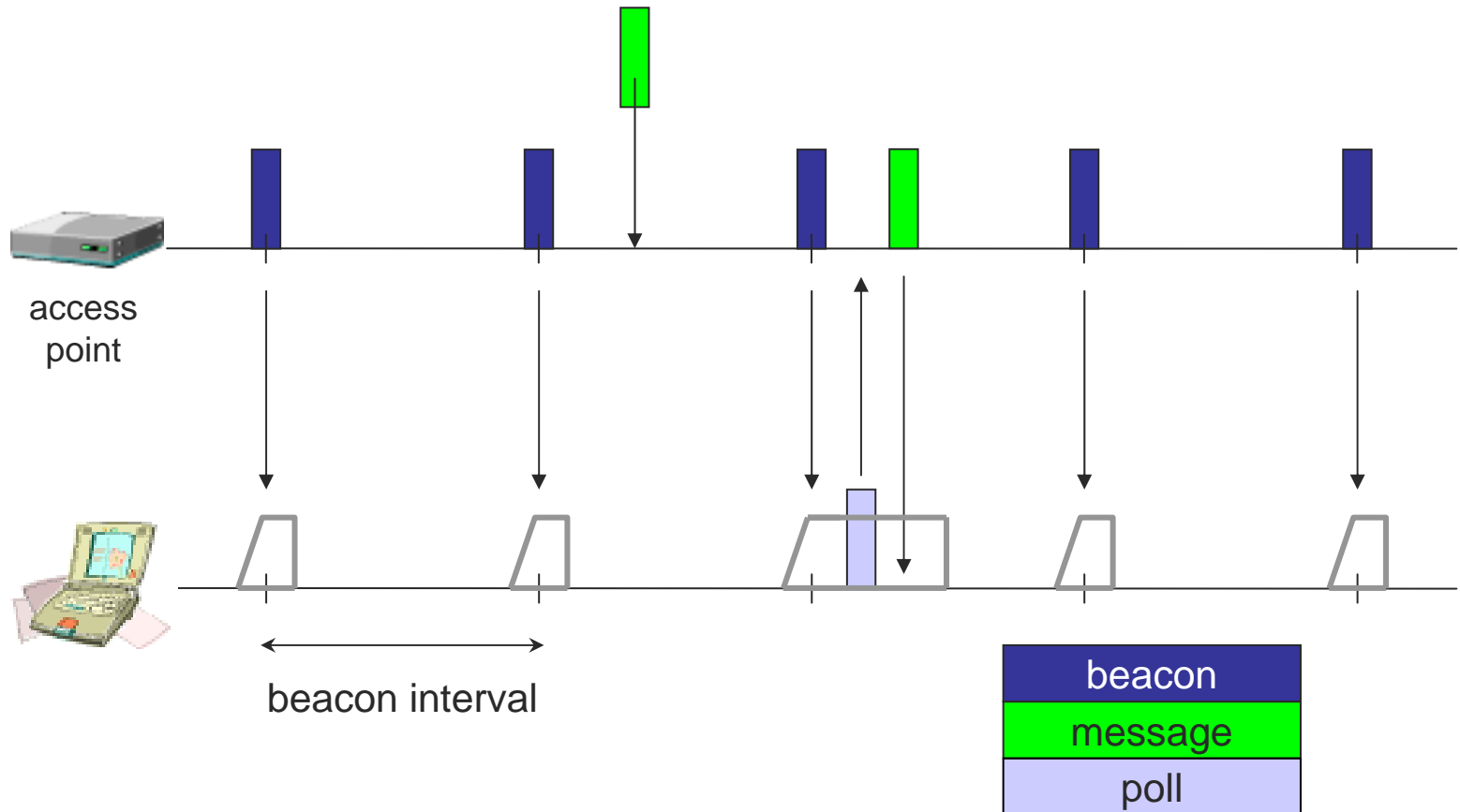
beacon interval

| beacon |
| message |
| poll |
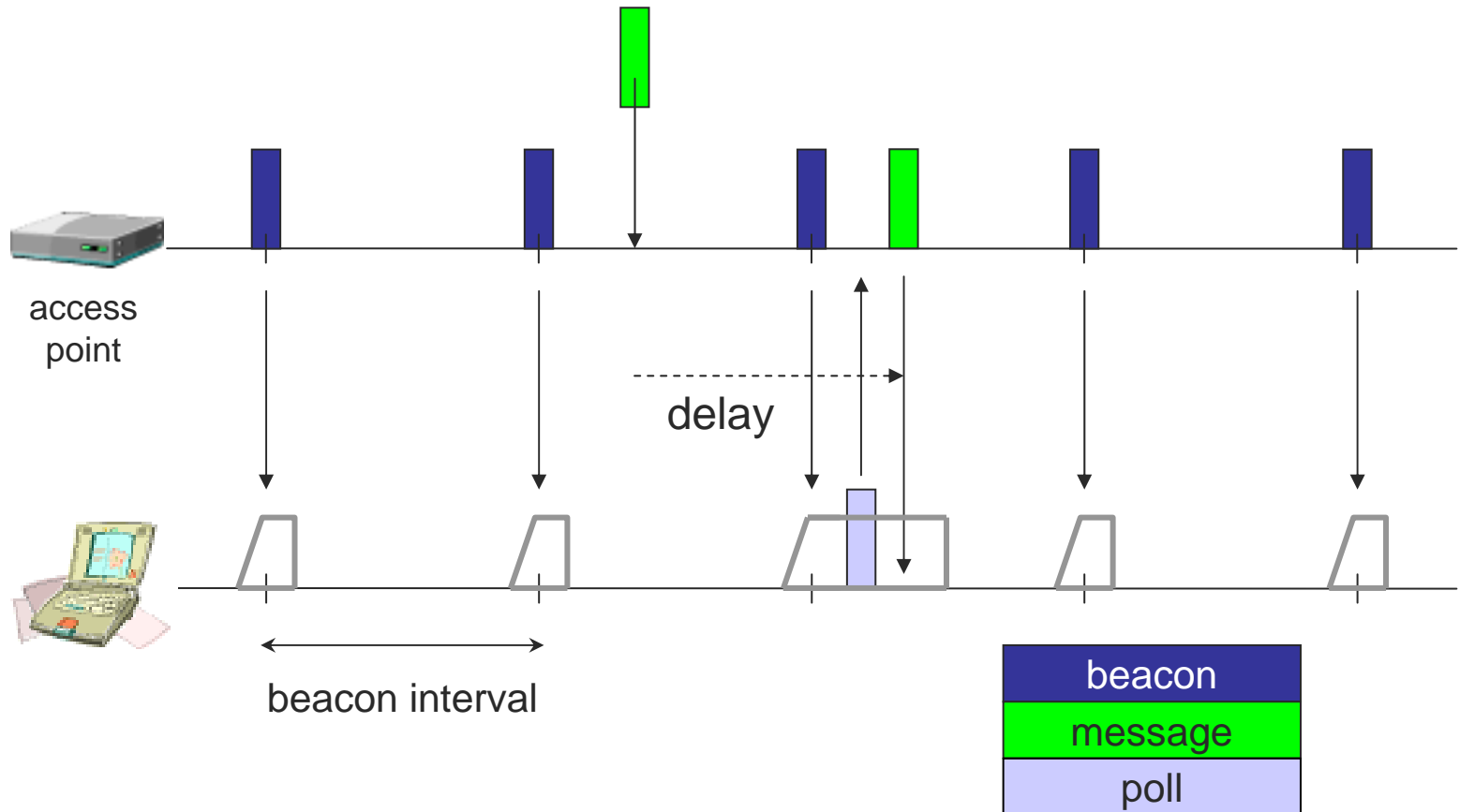
Impact on RPC Operations (NFS)

- `find` over NFS

mode	Idle mode	100ms beacons	500ms beacons
time	1.2s	48.3s	191s

- RPCs are not issued concurrently
- ⇨ only one RPC completed during beacon interval
- ⇨ NFS time-outs and retransmissions increase time and energy consumption

Effects on Application Performance

NFS

Other applications?

negative impact on
application performance

little or no impact on
application performance

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Effects on Application Performance

- What are the effects on other applications?

NFS   **Copy / Download**

← negative impact on application performance   little or no impact on application performance →

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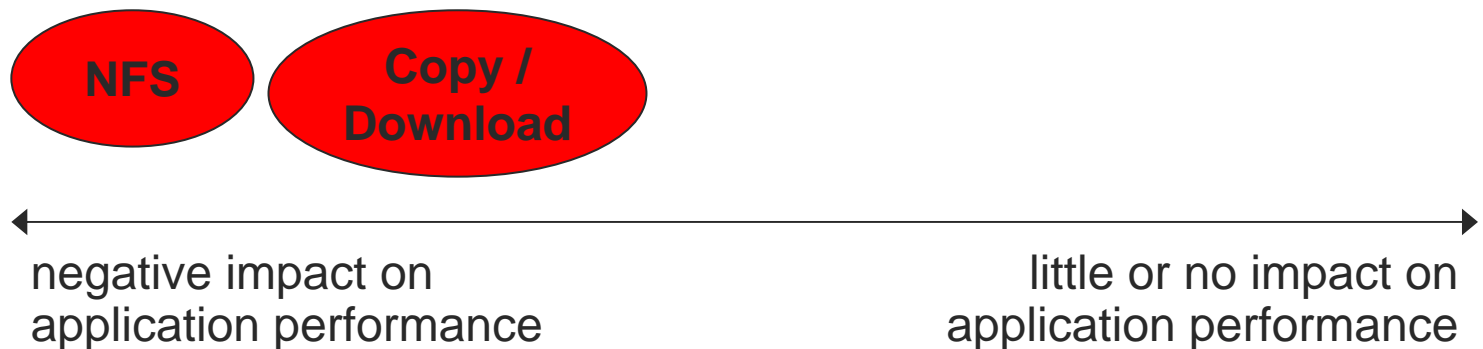
Effects on Application Performance

- Interactive applications

negative impact on
application performance

little or no impact on
application performance
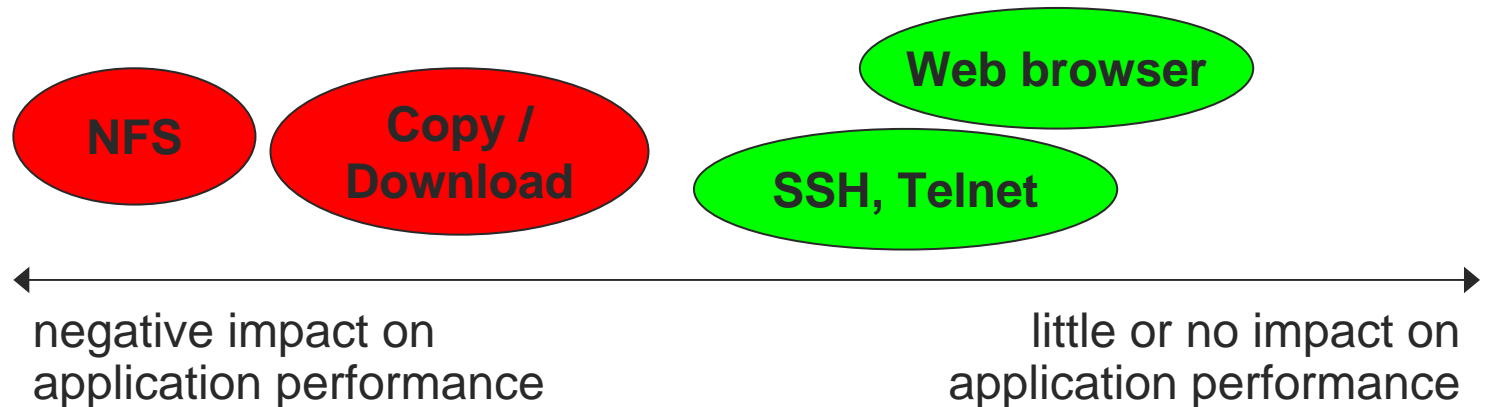
Effects on Application Performance

- Multimedia streams

NFS

Copy / Download

SSH, Telnet

Web browser

Stream

negative impact on
application performance

little or no impact on
application performance
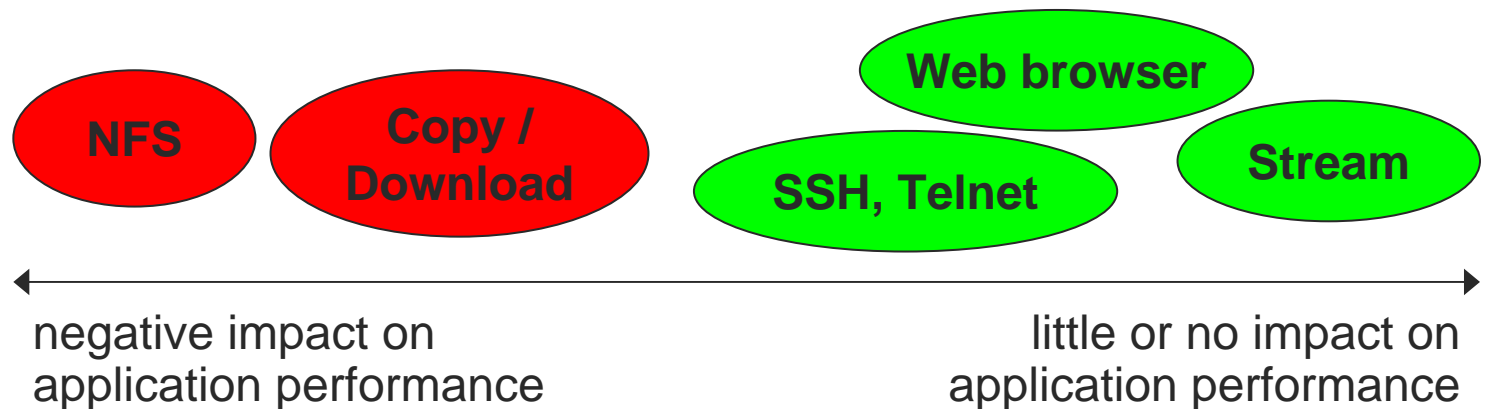
So far …

- IEEE Standard defines simple, effective power management algorithm

- User-perceived effects on performance vary from application to application

Consequences

- IEEE Standard defines simple, effective power management algorithm

- User-perceived effects on performance vary from application to application

- → Adapt power management depending on currently active application

- → We need a method to reliably identify application profiles during runtime

Approaches to Profile Identification

- Port numbers, protocol, TCP flags
  - firewalls, tunneling, dynamically assigned ports

- Packet introspection
  - high overhead

- Identification based on characteristics of network communication
  - already monitored by operating system (or the card itself)
  - directly reflects device usage

Network Characteristics

- **Available information**
    - number of packets received & sent
    - volume received & sent

- **Derived characteristics**
    - average size of packets received (sent)
    - ratio and standard deviation of average packet sizes
    - average length of active or inactive periods
    - ratio and standard deviation of these lengths (periodicity)
    - …

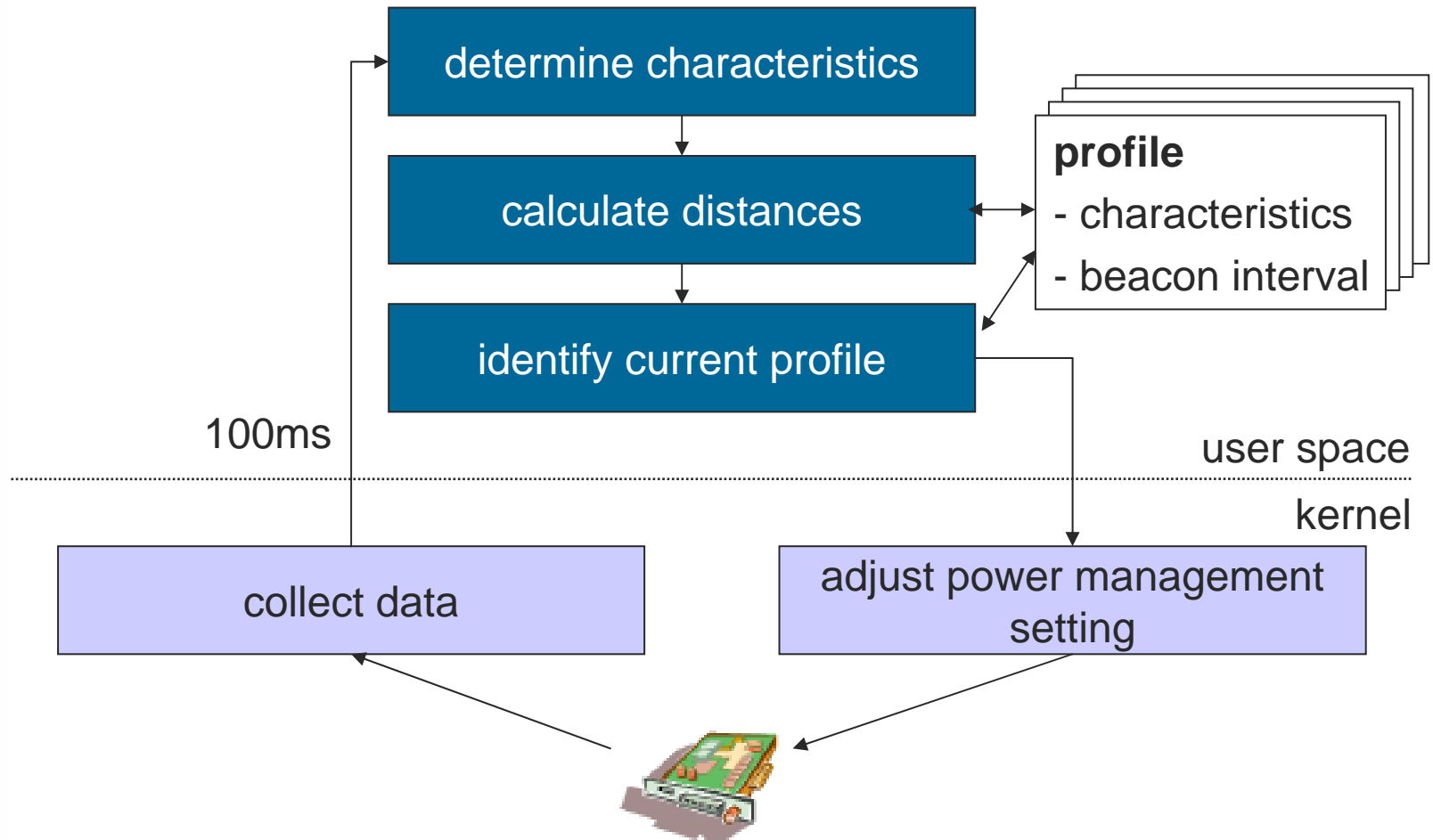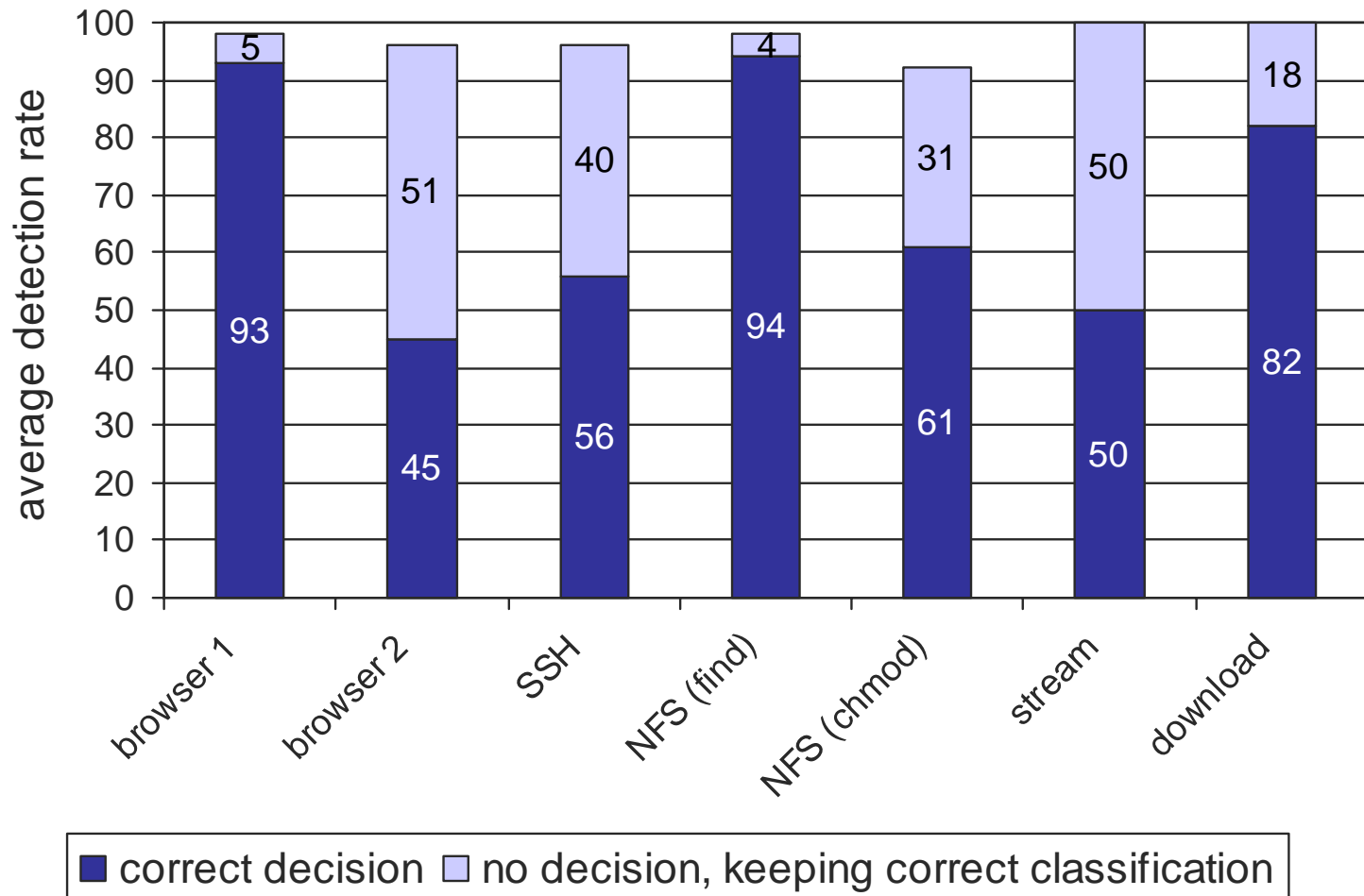- **Determine typical characteristics of different applications**

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Application Profiles

- **Browser (Mozilla)**
  - high ratio of inactive to active periods, high deviation of length of inactive periods

- **SSH, Telnet session (mutt, vi, ...)**
  - very small packets

- **RPC operations: NFS (find, kernel compile run)**
  - short inactive periods

- **Download/Copy (FTP)**
  - very large packets, very short inactive periods

- **Stream (Netradio, Realplayer)**
  - periodic data transmission (very low deviation of the length of inactive periods)

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Implementation


```
determine characteristics
        |
        v
calculate distances  <-->  profile
        |                  - characteristics
        v                  - beacon interval
identify current profile
```

100ms

user space

kernel

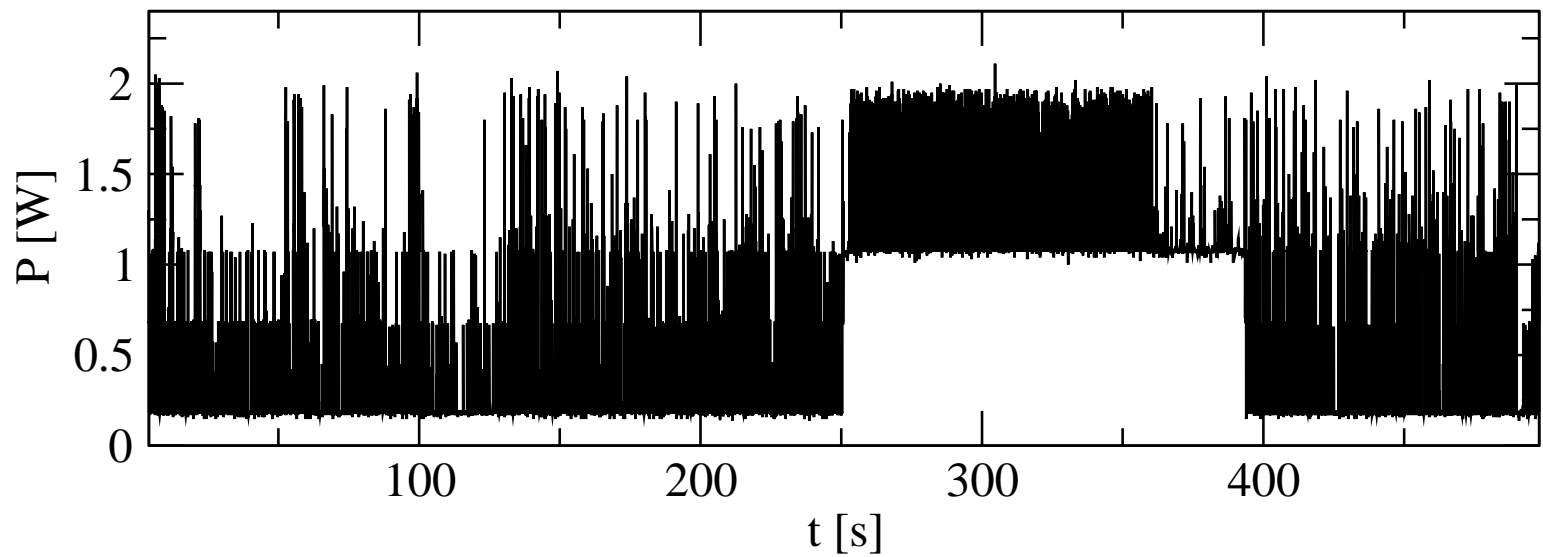collect data

adjust power management setting
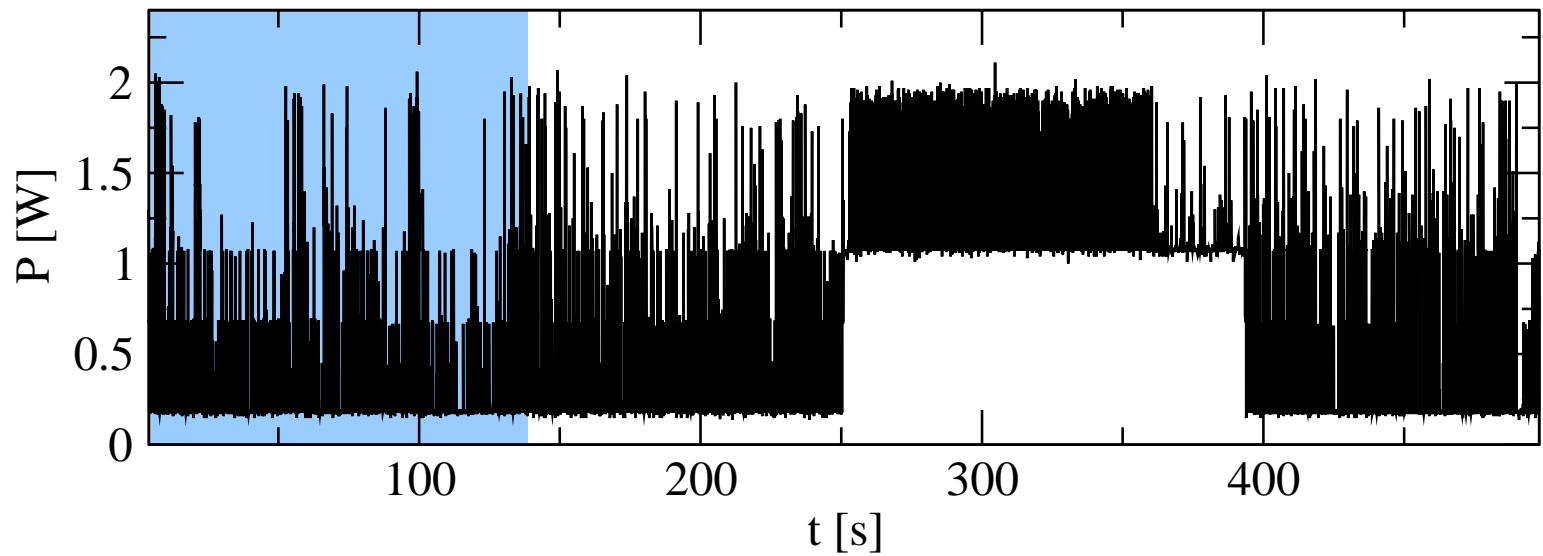
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Evaluation

Online Application Characterization

- Testing a live system
  - switch between browser, SSH, NFS and audio stream
  - monitor decisions of characterization demon
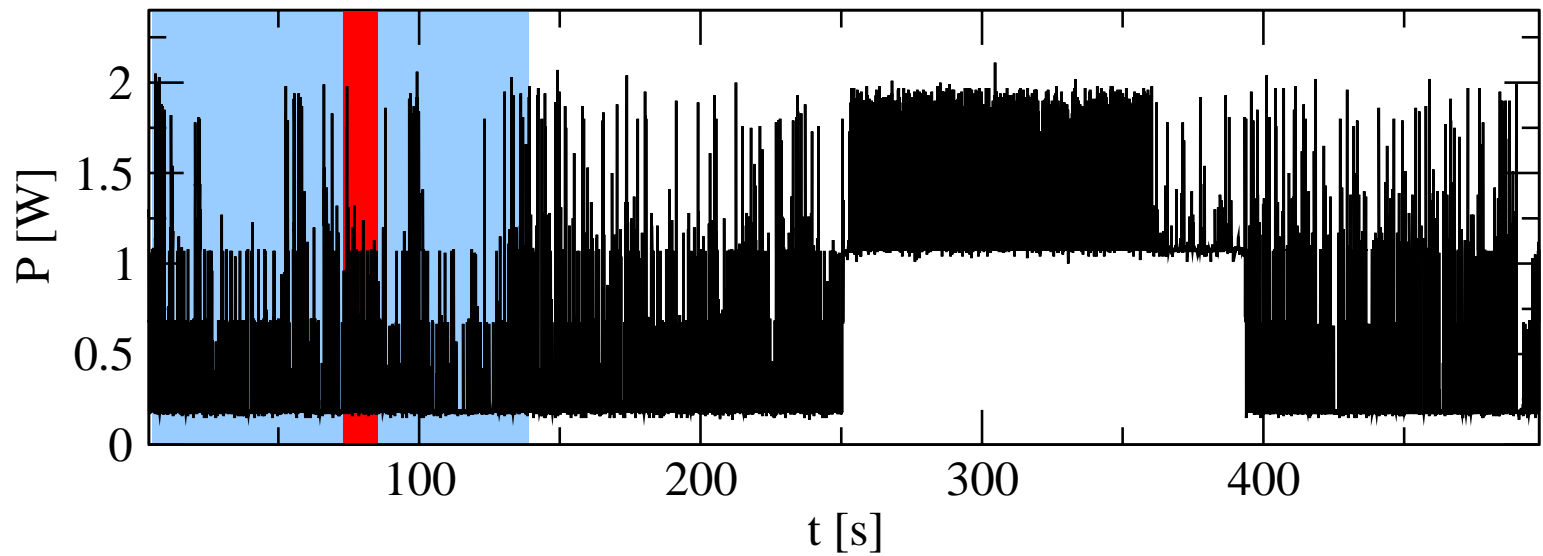 - compare to actual application run times

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Mozilla

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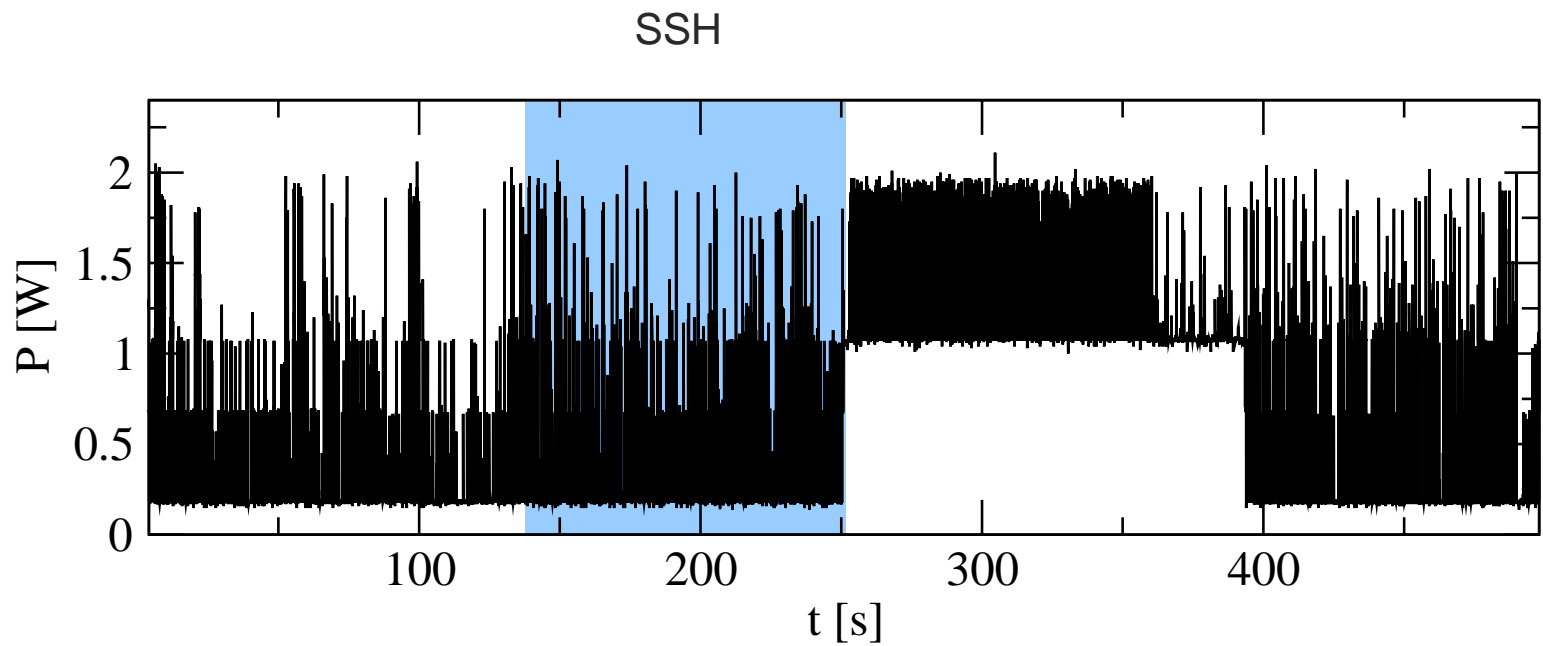 - compare to actual application run times

SSH

Online Application Characterization
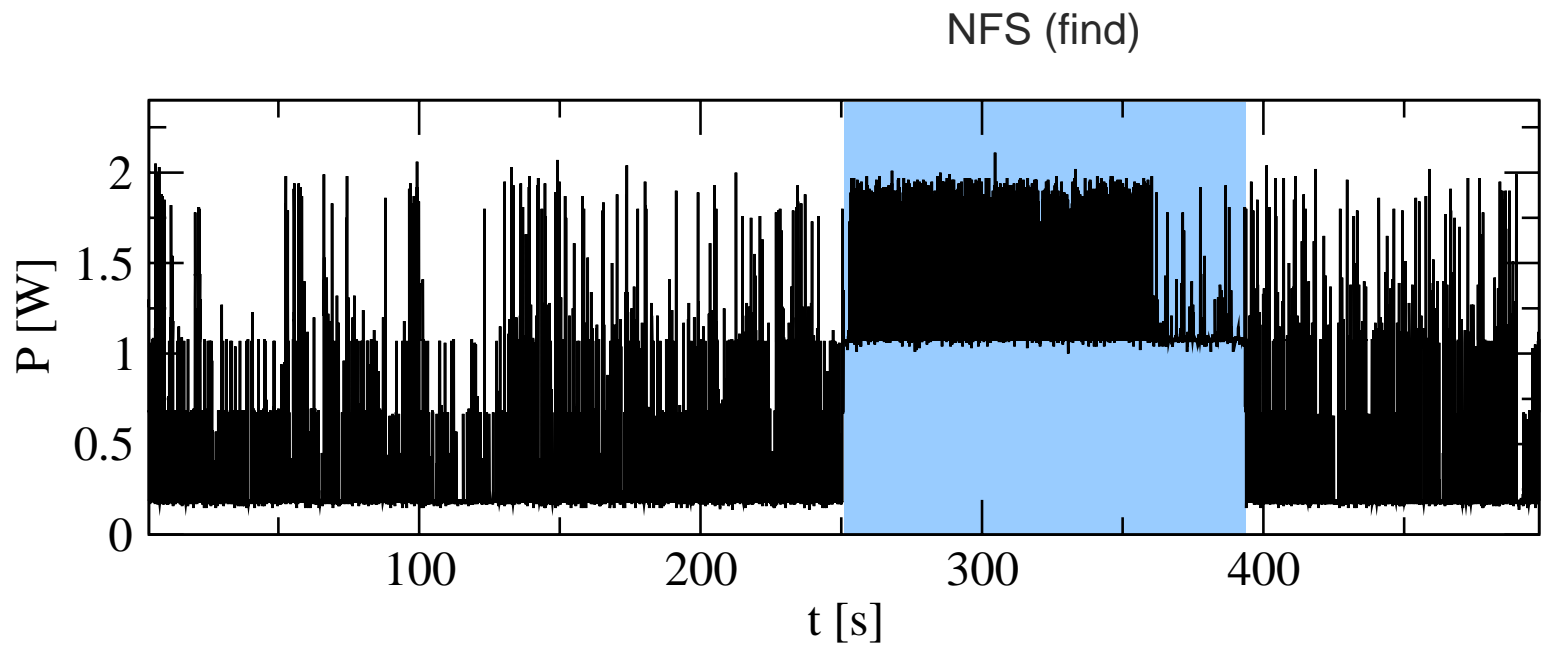
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SSH

Online Application Characterization
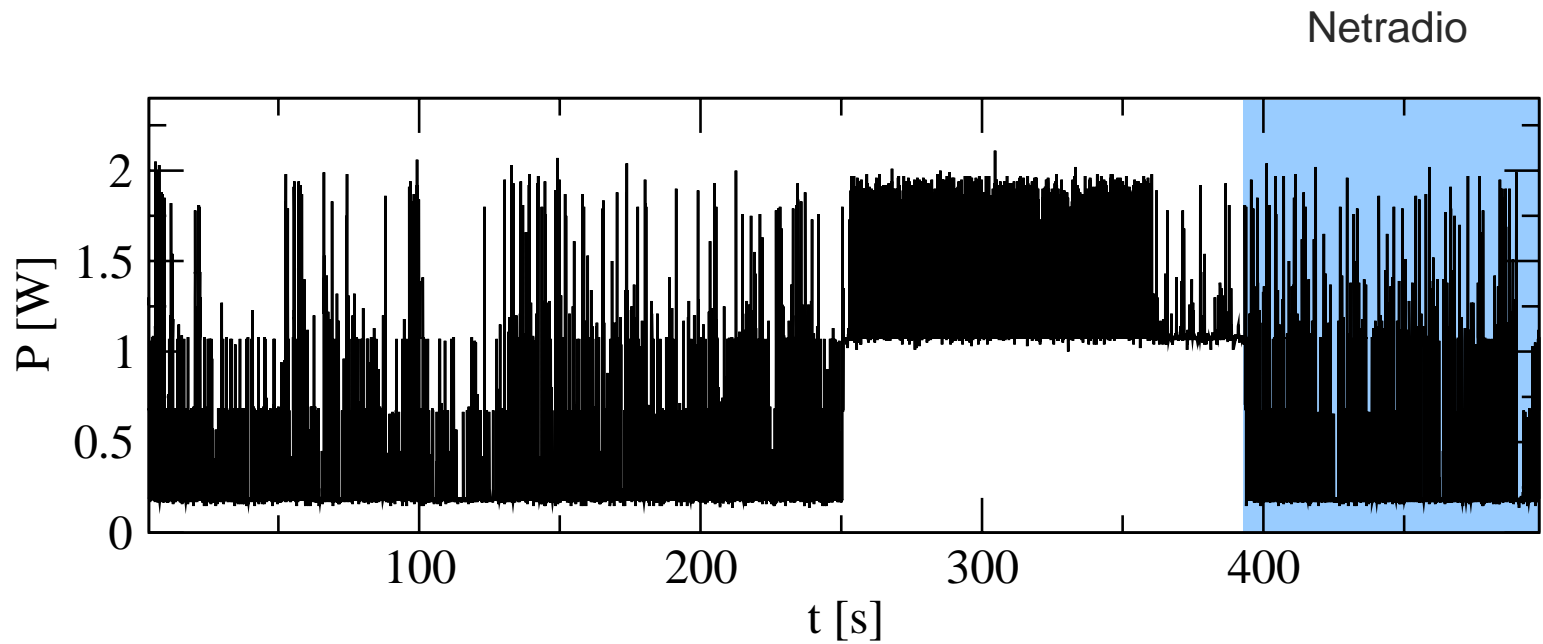
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NFS (find)

- **Testing a live system**
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  - compare to actual application run times

Netradio

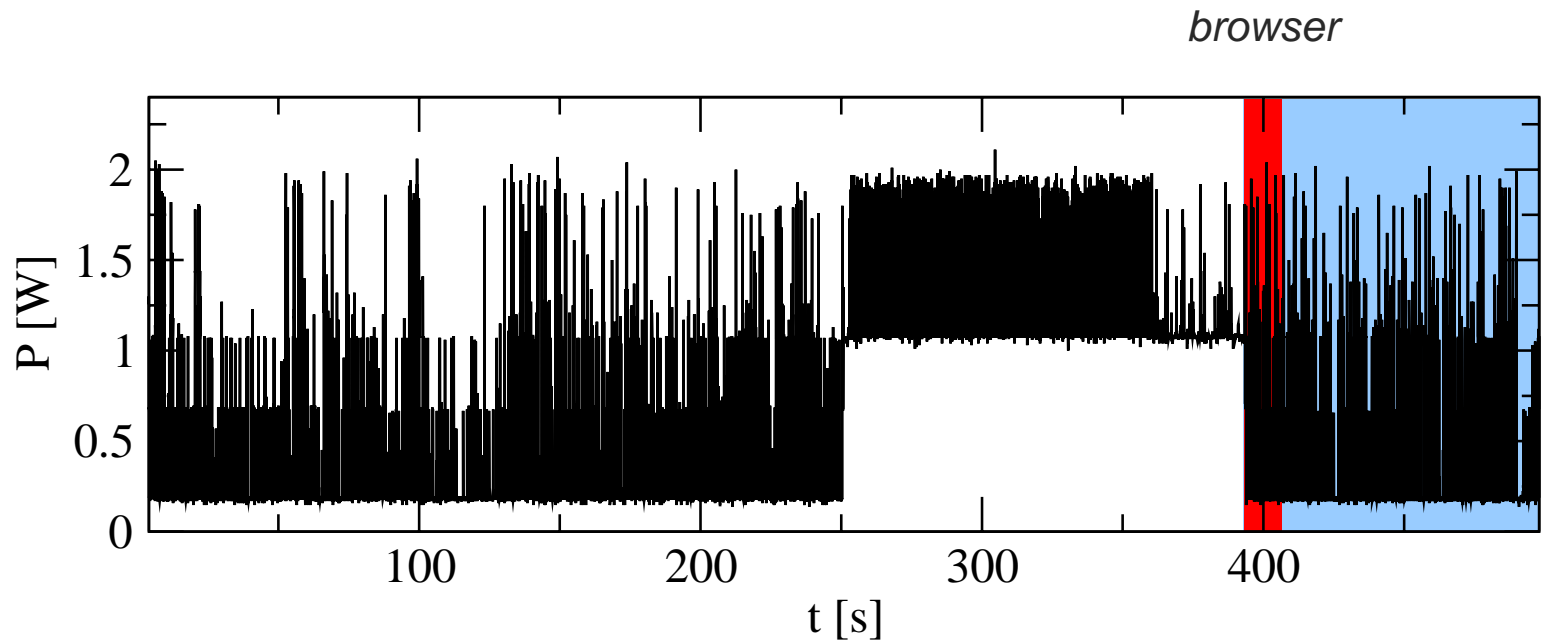# Online Application Characterization

- **Testing a live system**
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  - compare to actual application run times

browser

Comparison with PSP/CAM

- The card's own adaptive power management mode
    - activate power saving mode depending on network traffic
    - wait for 2 seconds before switching back to sleep mode

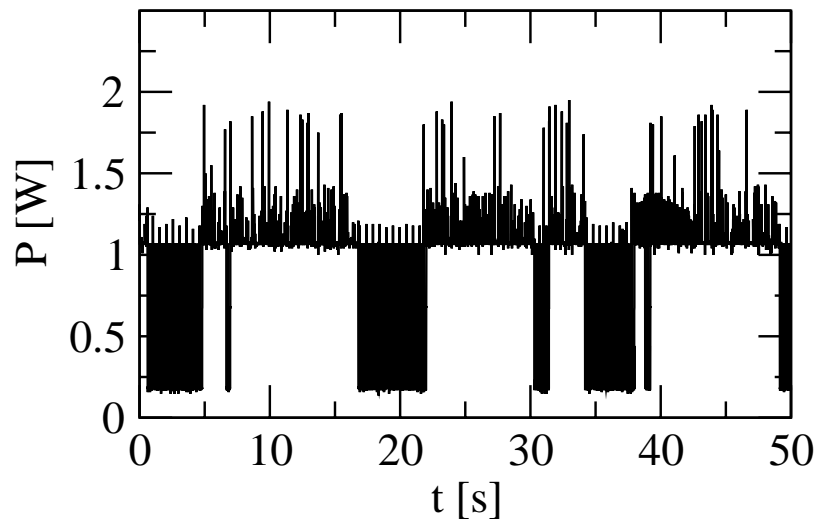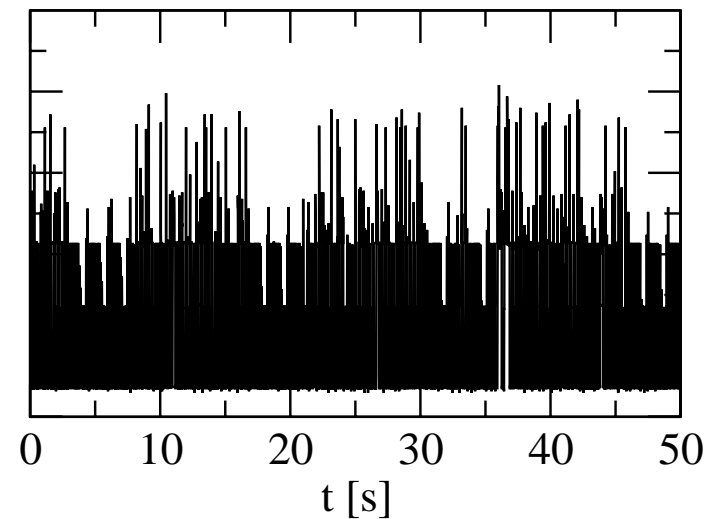# Comparison with PSP/CAM

- The card's own adaptive power management mode
  - activate power saving mode depending on network traffic
  - wait for 2 seconds before switching back to sleep mode

  - power consumption of low-bandwidth Real audio stream:

PSP/CAM: 41.5 J (50s)   100ms beacons: 19.1 J (50s)

Applications Running in Parallel

- **Browsing the web while listening to an audio stream**
  - detection of both applications,
    frequently switching between the two profiles
  - ⇨ choose the profile which is more sensitive to delays

- **Using SSH while listening to an audio stream**
  - no profile detected during the whole test run
  - ⇨ switch to user-specified default setting

- **Capture network statistics for each process**
  - ⇨ future work

Conclusion

- IEEE 802.11 power management adds delays when receiving network packets

- The optimal energy/performance trade-off depends on the application and the user

- On-line identification of application profiles based on network characteristics

- Activate user-specified power management setting depending on the identified profile

- Reliable identification mechanism

Thank You!