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Annotation Based Multimedia Streaming Over Wireless Networks

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Outline

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- Data Annotation
- System Architecture
- Our Approach
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- Buffering
- MPEG Stream
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- Conclusions

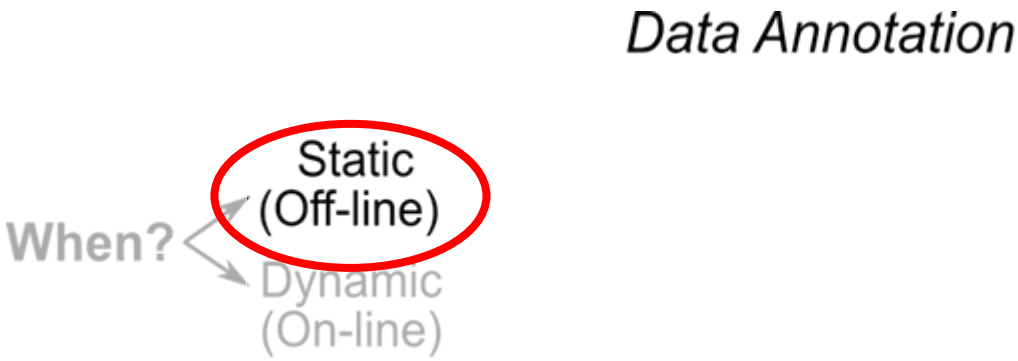
Motivation

- **Multimedia streaming**
  - Increasingly popular on mobile devices
- **Network card**
  - 30 % of overall energy (or even higher)
  - Power optimization challenging
    - ✧ Only option: low power mode
    - ✧ Few opportunities, due to streaming

- **We propose a new annotation-driven burst-type transmission that maximizes idle times**
  - Between bursts network card -> low power mode
  - Improved energy savings for network interface

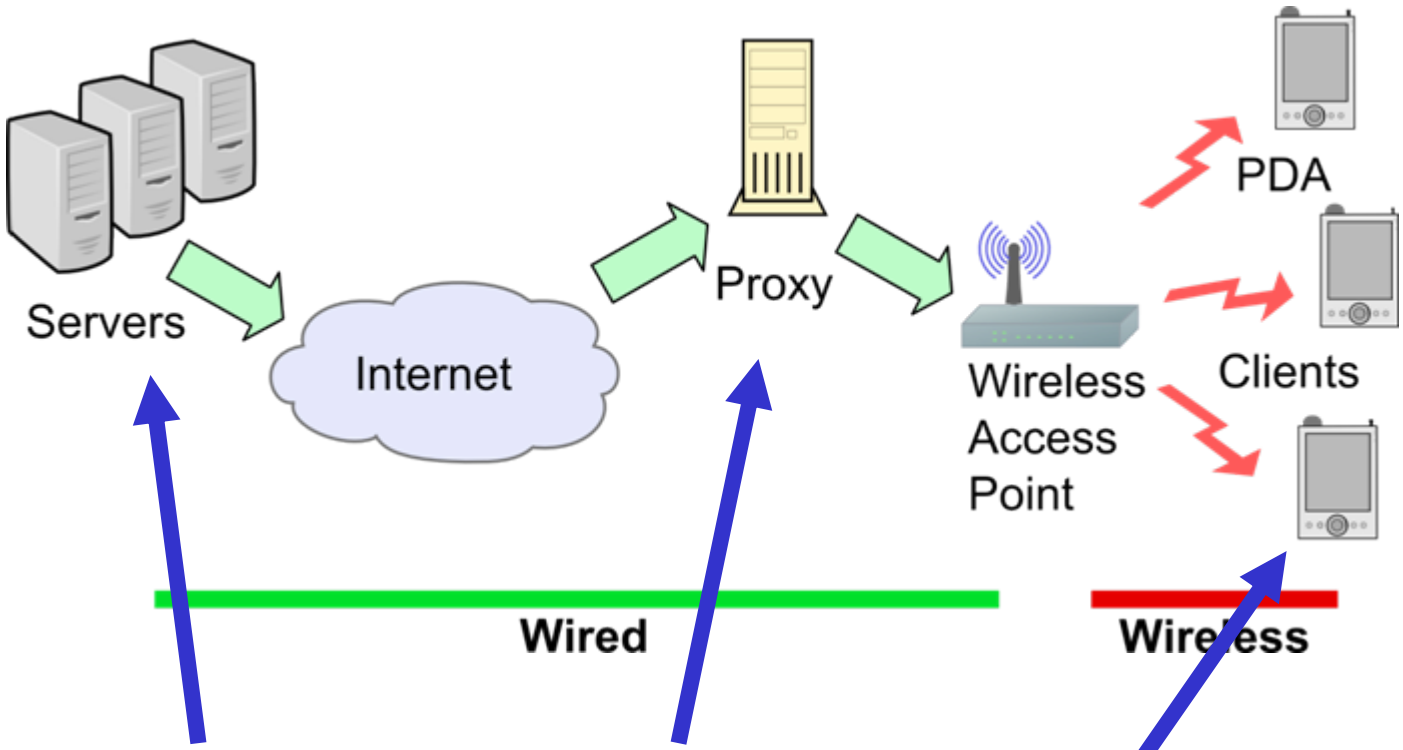
Data Annotation

- **Types of annotations:**



- **This paper**
  - **Focus on network level (wireless card)**
  - **Application: multimedia streaming (MPEG encoded content)**
- **Advantages**
  - **No overhead at runtime**
  - **More optimizations possible (better and early information)**

System Architecture



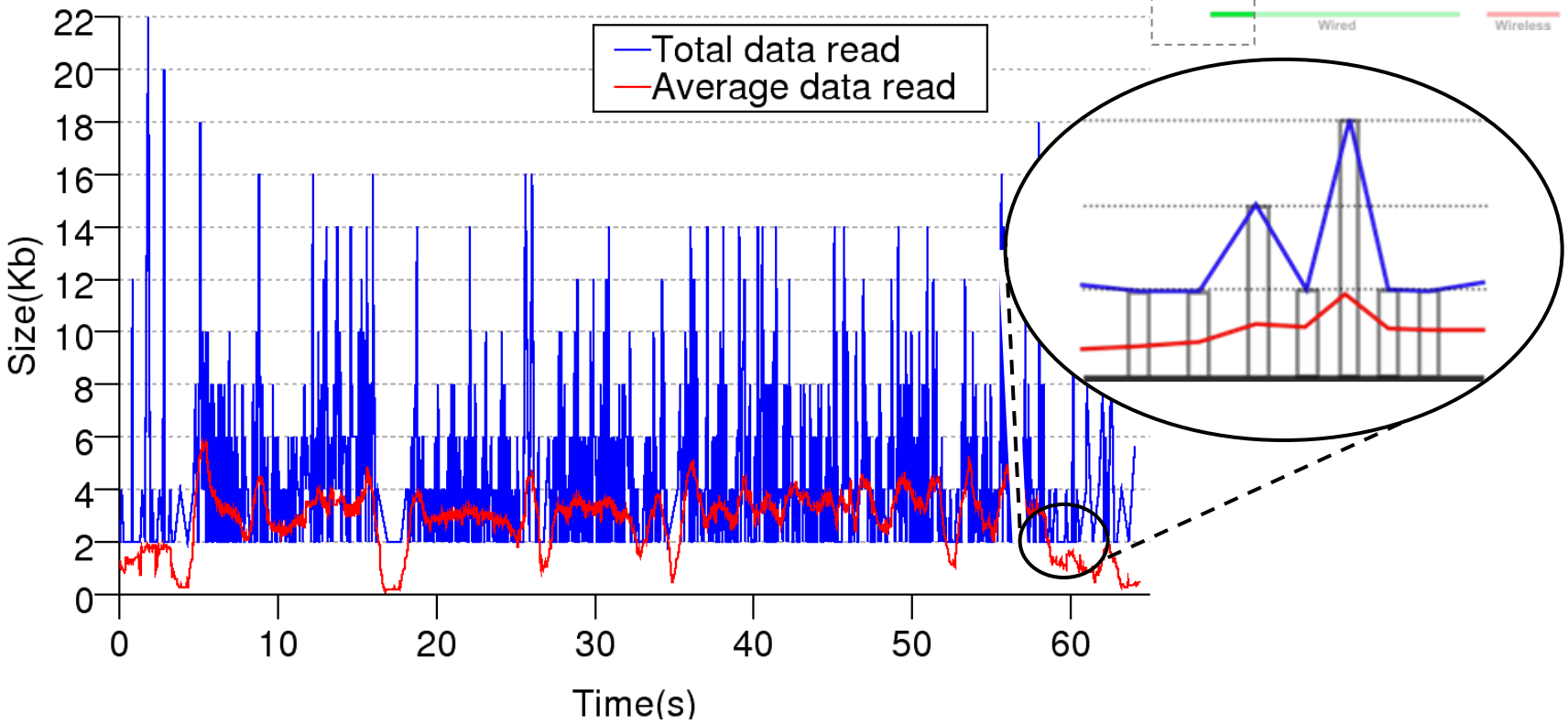
- ✧ **Annotations can be inserted at either**
  - ✧ **server node**
  - ✧ **proxy node**
- ✧ **Annotations are used at the client end**

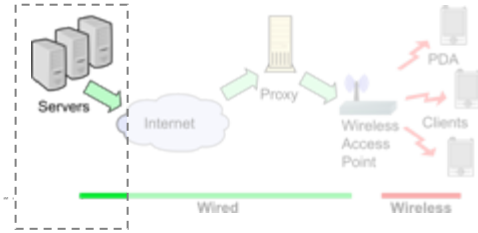
Steps in Our Approach

- At server, each video stream is preprocessed
  - Annotations about bitrate is recorded in the stream
- During transmission
  - Wireless access point: intelligently schedules bursts for each client separately
  - Client network interface: improved buffering mechanism
    - ✧ Ensures data is always available when the decoder requests it
    - ✧ Decision for filling up the buffer is based on annotations
      - ✧ Reduced buffer size with minimal or no frame loss
- At runtime
  - Video decoder parses the MPEG stream
    - ✧ Reads packets from network interface as required
  - Content is presented to the user

Preprocessing and Annotation

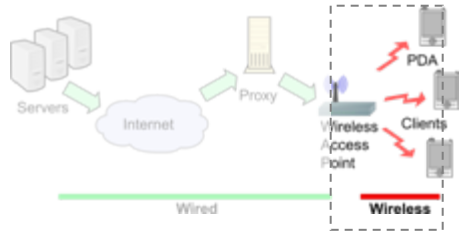
- **Typical bitrate variation during clip playback:**





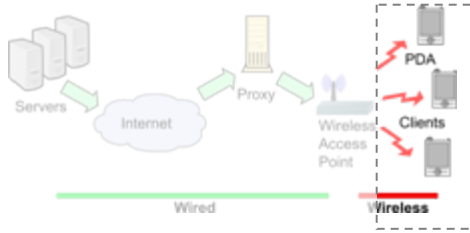
- **Actions:**
  - **Collect packet consumption rates (size, time)**
  - **Add annotations to stream**

Wireless Network

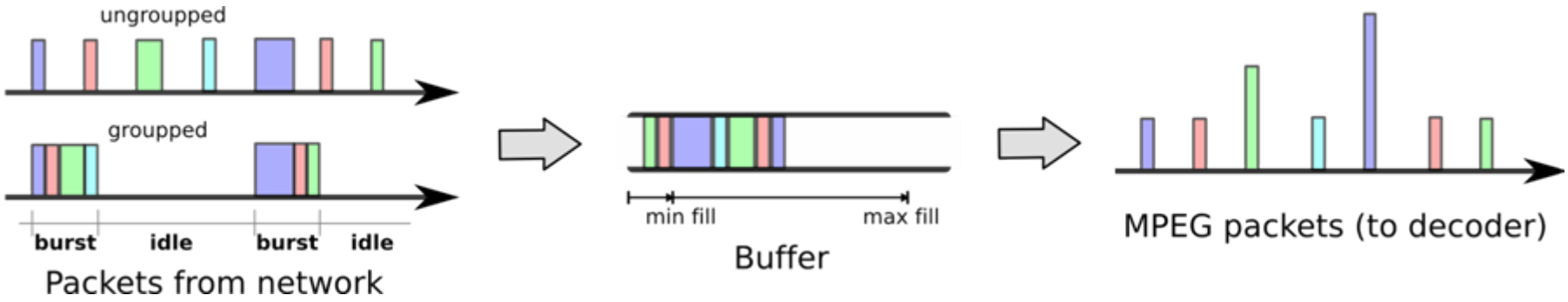


- **IEEE 802.11 Protocol**
  - **Built-in power management (PSM)**
  - **Originally intended for sporadic data transfer**
    - ✧ **Rendezvous approach**
    - ✧ **Periodic (100ms) beacons**
      - ✧ **Can go to low power (sleep) mode between beacons, if no data**
  - **Sub-optimal power performance for streaming**
    - ✧ **Requires continuous, periodic data transfer**
- **Solutions:**
  - **Traffic shaping mechanism [Surendar 2002]**
    - ✧ **Traffic buffered into larger bursts, history-based prediction**
      - ✧ **Packet drops occur when prediction proves wrong**
    - ✧ **Network card switched into low power mode when idle**
  - **Annotation-based mechanism**
    - ✧ **Similar to above, uses annotations for higher accuracy**
    - ✧ **No frame loss (or minimal)**

Buffer Management

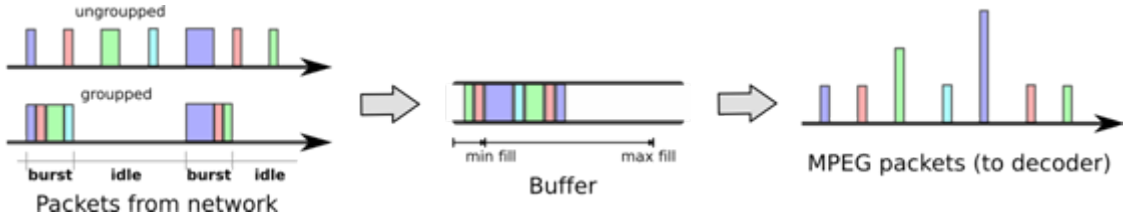


- **Buffering required**
  - **Stores content sent in bursts**
  - **Simple algorithm for refilling**
    - ✧ **Min, max thresholds**
    - ✧ **When empty, requests burst transmission from server**

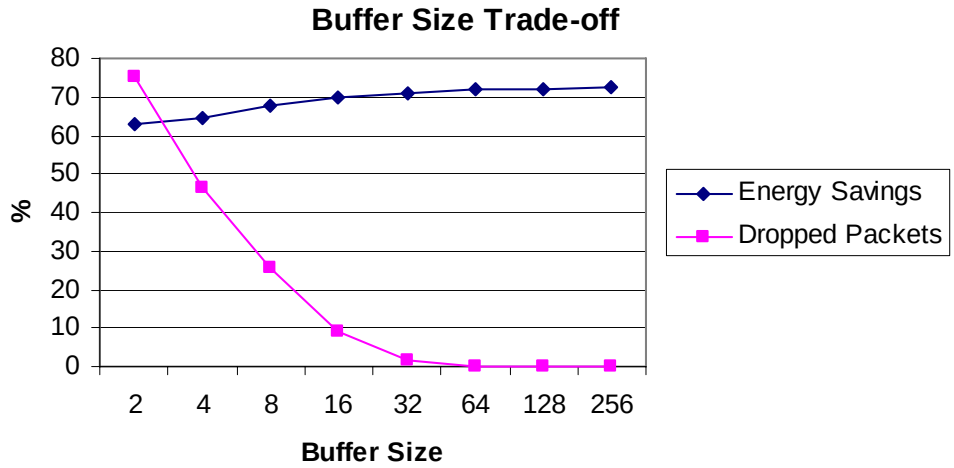


- **Original stream: frames are not grouped**
- **Modified stream: burst transmission, longer idle times**

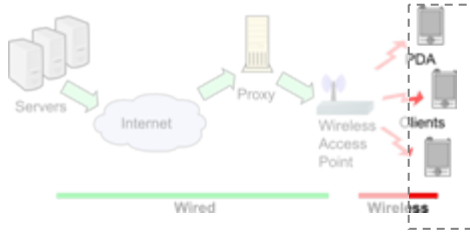
Buffer Sizing



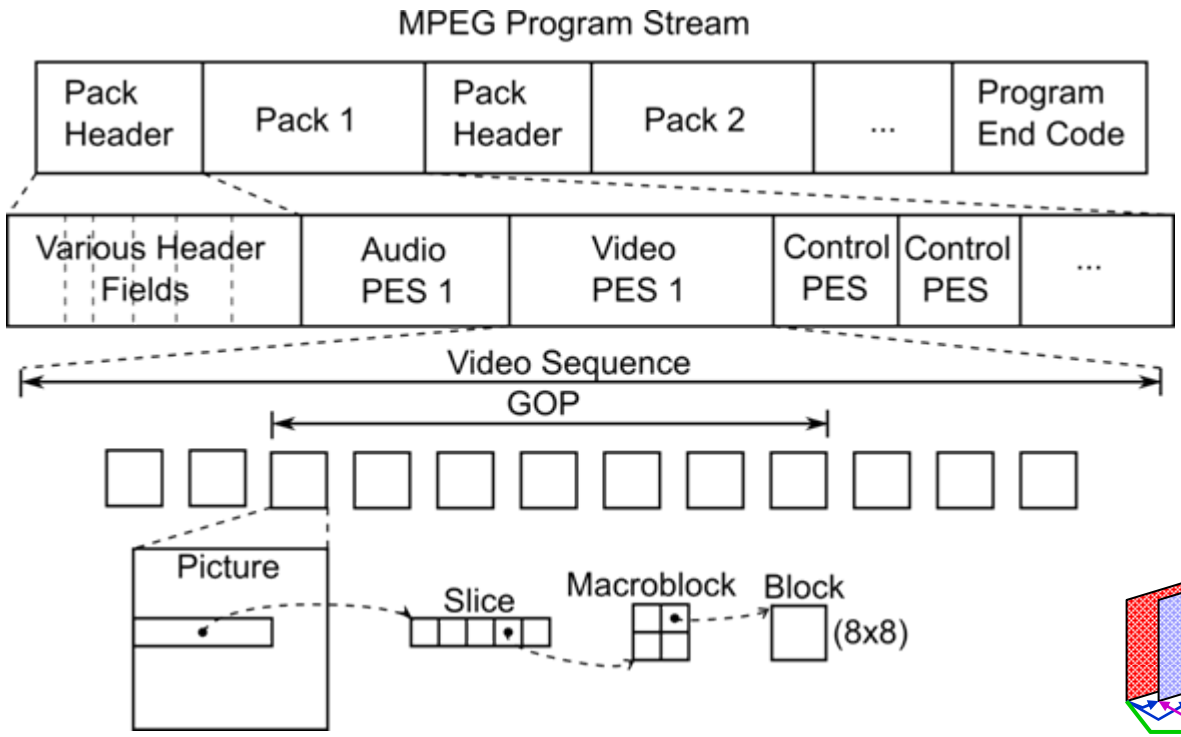
- **Tradeoff**
  - **Too small**
    - ✧ **shorter idle periods, higher packet drop rates**
  - **Too large**
    - ✧ **longer delays**
- **Chose 64Kb based on experiments**
  - **No significant gains going higher**

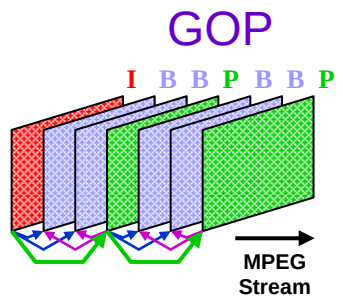


MPEG Stream Format

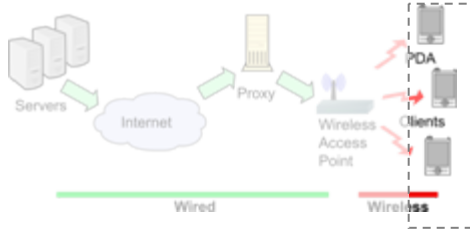


- **Hierarchical organization**
  - **Data consumption very regular**
  - **Annotations describe patterns (size, time)**
    - ✧ **Relatively small overhead (bytes vs tens of Kb)**

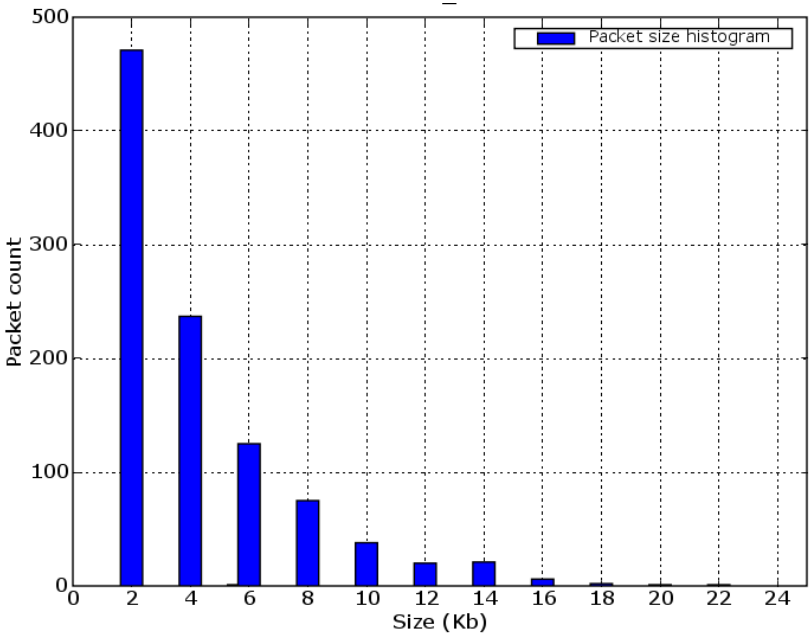




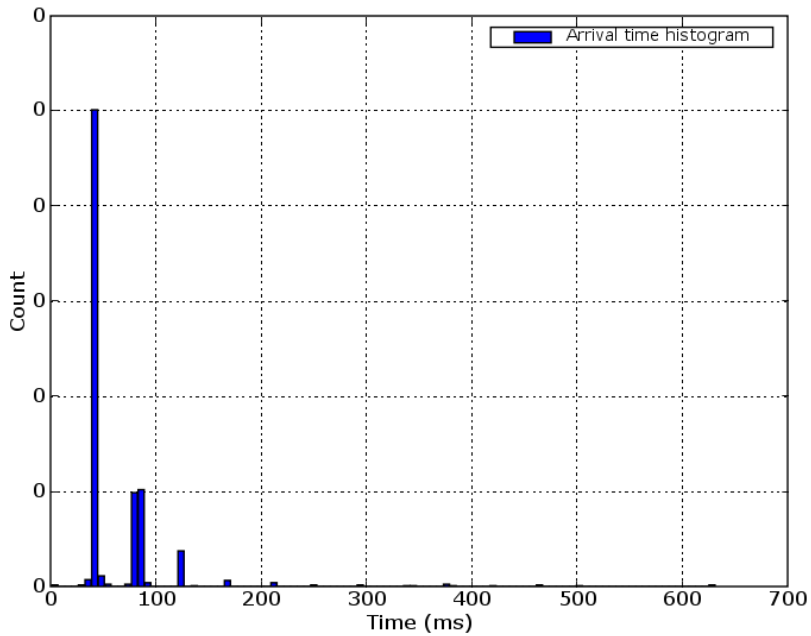
MPEG Packet Arrival



- **Profiling results**
  - **Packet size distribution – multiples of 2Kb**
  - **Arrival time – averages around multiples of 40ms**
    - ✧ **Few opportunities for IEEE 802.11 power management (100ms)**
  - **Regular behavior due to MPEG packetization and frame rates**

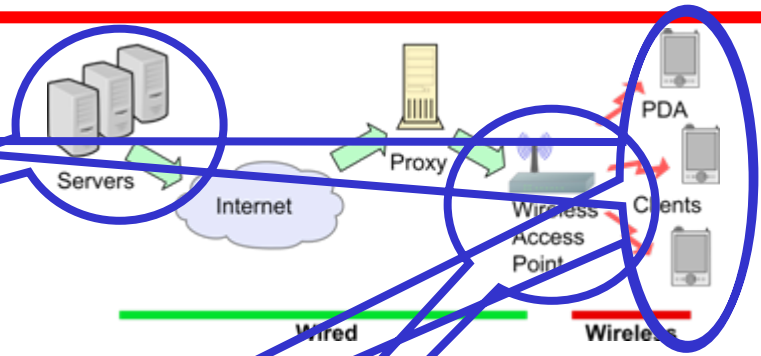


Packet Size



Arrival Time

Experimental Setup

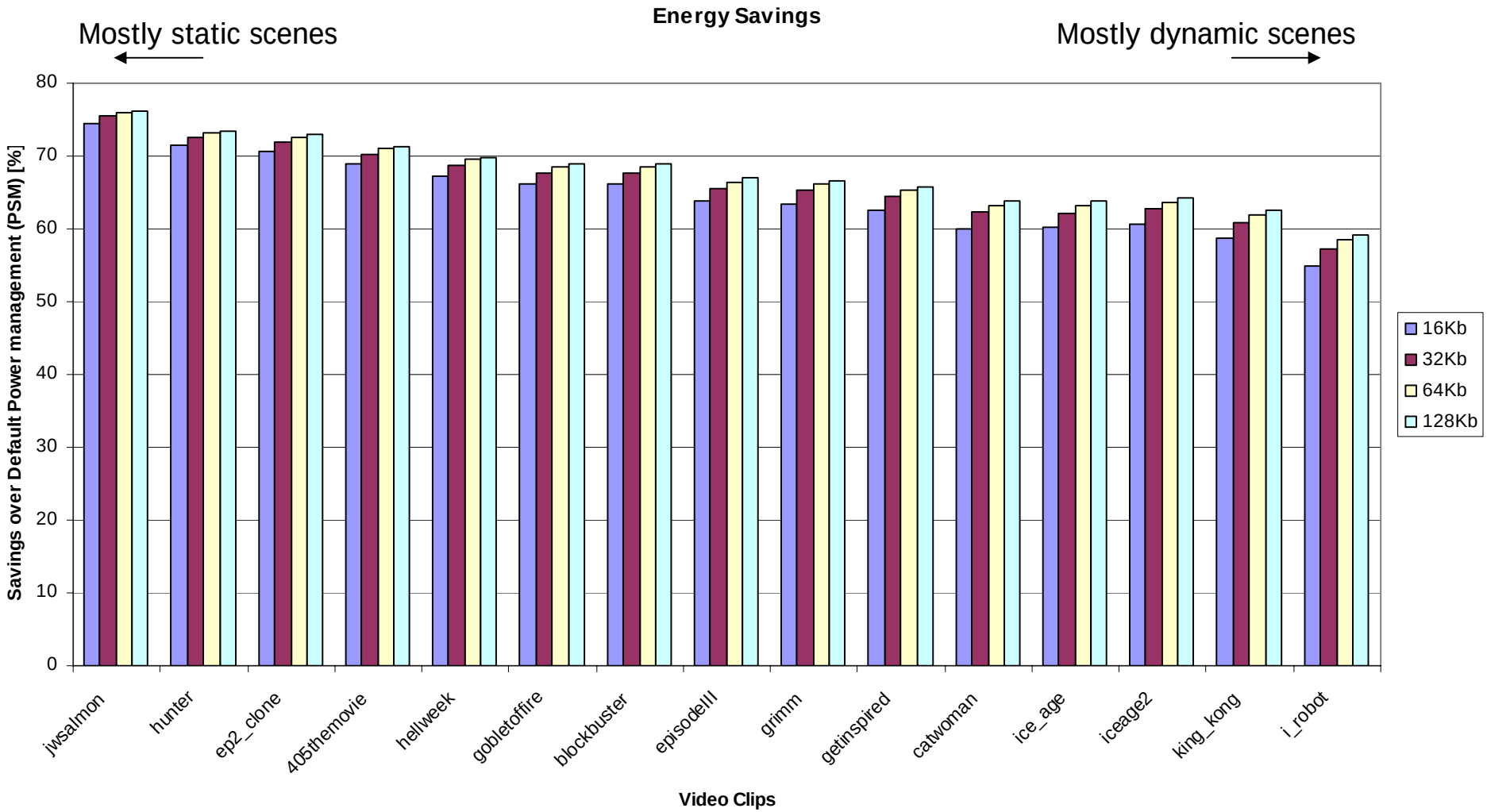


- **PDA client: iPAQ 5555**
  - Video player: Berkeley MPEG Tools
- **Media Clips**
  - PDA formatted: 320x200, bitrates 38Kbps – 82Kbps
  - Running times: 1 to 12 minutes
  - Action, animations, commercials, short films
    - ✧ Different bitrate consumption patterns
- **Network Card**
  - 2.4 GHz Wavelan
    - ✧ 1.67 W transmit, 1.43 W receive, 1.32 W idle, 0.18 W sleep
    - ✧ Sleep -> active: 250 microseconds
      - ✧ wake up network ahead of time (10ms)
- **Wireless access point**
  - Intelligently schedules bursts for each client

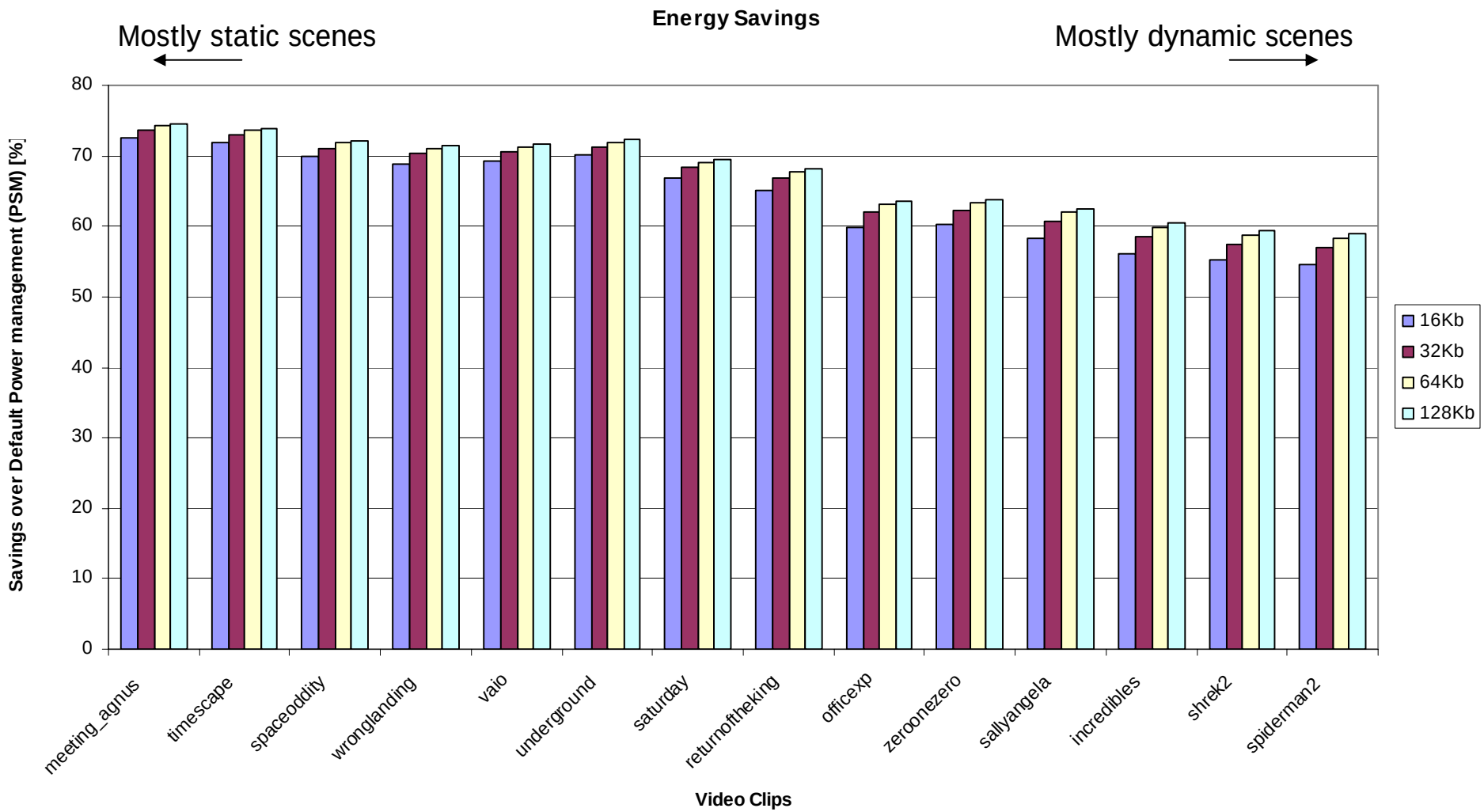
Experiments Performed

- **First step: profiled and annotated all media clips**
- **Next: multimedia streaming**
  - **Measured energy savings and drop rates**
- **Variable buffer size: 16 Kb – 128 Kb**
  - **Studied the effect on energy savings and packet drop rates**
- **Dynamic scenes effect on energy and drop rate**
  - **Mostly dynamic clips vs mostly still clips**
- **Baseline for energy comparisons**
  - **Default IEEE 802.11 power saving mode (PSM)**

Energy Savings (1)



Energy Savings (2)



Energy Savings and Drop Rates

	Energy Savings (%)				Package Drop (%)			
Video Clip	16Kb	32Kb	64Kb	128Kb	16Kb	32Kb	64Kb	128Kb
catwoman	60.01	62.24	63.27	63.79	1.80	0.00	0.00	0.00
405themovie	68.95	70.27	70.96	71.31	4.32	0.50	0.00	0.00
blockbuster	66.20	67.77	68.55	68.95	0.00	0.00	0.00	0.00
ep2_clone	70.72	72.01	72.60	72.92	0.00	0.00	0.00	0.00
episodeIII	63.83	65.61	66.47	66.93	1.38	0.00	0.00	0.00
getinspired	62.50	64.38	65.34	65.82	4.49	0.00	0.00	0.00
grimm	63.50	65.29	66.20	66.65	0.87	0.00	0.00	0.00
hellweek	67.21	68.75	69.50	69.88	1.59	0.00	0.00	0.00
gobletoffire	66.13	67.72	68.51	68.93	1.47	0.00	0.00	0.00
hunter	71.43	72.62	73.20	73.50	0.00	0.00	0.00	0.00
iceage2	60.68	62.68	63.68	64.18	2.67	0.00	0.00	0.00
ice_age	60.19	62.13	63.25	63.78	5.66	0.00	0.00	0.00
i_robot	54.80	57.28	58.60	59.21	8.75	0.00	0.00	0.00
jwsalmon	74.55	75.50	75.97	76.18	0.00	0.00	0.00	0.00
king_kong	58.64	60.80	61.91	62.45	2.00	0.29	0.00	0.00
meeting_agnus	72.56	73.73	74.28	74.56	0.28	0.00	0.00	0.00
officexp	59.78	61.92	63.02	63.60	10.17	0.00	0.00	0.00
returnoftheking	65.13	66.85	67.67	68.10	1.11	0.00	0.00	0.00
sallyangela	58.31	60.82	61.92	62.46	0.14	0.00	0.00	0.00
vaio	69.19	70.66	71.33	71.66	0.00	0.00	0.00	0.00
saturday	66.84	68.36	69.11	69.51	1.24	0.00	0.00	0.00
shrek2	55.16	57.44	58.76	59.41	22.99	0.57	0.00	0.00
spaceoddity	69.81	71.12	71.78	72.13	5.21	1.70	0.00	0.00
spiderman2	54.49	57.00	58.32	58.95	10.01	0.00	0.00	0.00
incredibles	56.22	58.61	59.84	60.44	9.55	0.00	0.00	0.00
timescape	71.87	73.07	73.63	73.92	0.61	0.00	0.00	0.00
underground	70.11	71.33	71.96	72.29	0.00	0.00	0.00	0.00
wronglanding	68.91	70.37	71.07	71.43	1.37	0.00	0.00	0.00
zeroonezero	60.17	62.24	63.32	63.83	4.87	0.00	0.00	0.00

Static scenes

Dynamic scenes

Analysis of Results

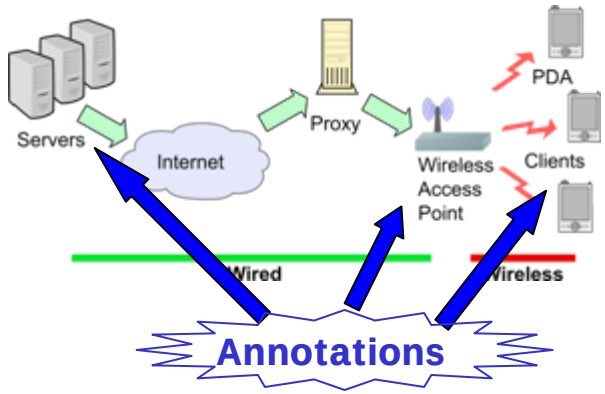
- 60-75% savings over the default power management in IEEE 802.11 (PSM)
- Very little increase over 64Kb
  - Smaller buffer may determine packet drops
- Clips with smaller packets perform best
  - Even for smaller buffer size
- Compared with previous results (Surendar et al.)
  - Similar energy savings
  - No packet drops over 64Kb buffer size
    - ✧ Prediction mechanism – up to 50% drop rate in the worst case
  - No decrease in video quality
  - Both are susceptible to network transmission errors

Related Work

- **Image transcoding**
  - Mesdat Group [2003], Chandra et al. [1999]
  - Still images (not applicable on video)
- **Bandwidth reduciton**
  - Tripathy et al. [2001]
  - Different goal (reduce bandwidth)
- **Traffic reshaping**
  - Chandra et al. [2002-2004], Wei et al. [2004]
  - Prediction mechanism, susceptible to frame loss
  - Our approach based on annotations (more accuracy)
- **Application-based network tuning**
  - Anand et al. [2005]
  - Different applications, not for one application

Conclusions

- Improved power management for network interface
- Annotation prove useful to improve accuracy
  - At server / access point
    - ✧ Bursts based on consumption rate
  - At client side
    - ✧ Buffer management
    - ✧ Better power savings
    - ✧ Zero or minimal frame loss



- Improved packet drop rate compared with previous approaches
- Future work:
  - Study network conditions and their effect on burst transmission
  - Impact of other clients on the wireless transfers
    - ✧ Network contention

Thank You!