



# Screen-Off Traffic Characterization and Optimization in 3G/4G Networks

Junxian Huang[1] Feng Qian[2] Z. Morley Mao[1]
Subhabrata Sen[2] Oliver Spatscheck[2]

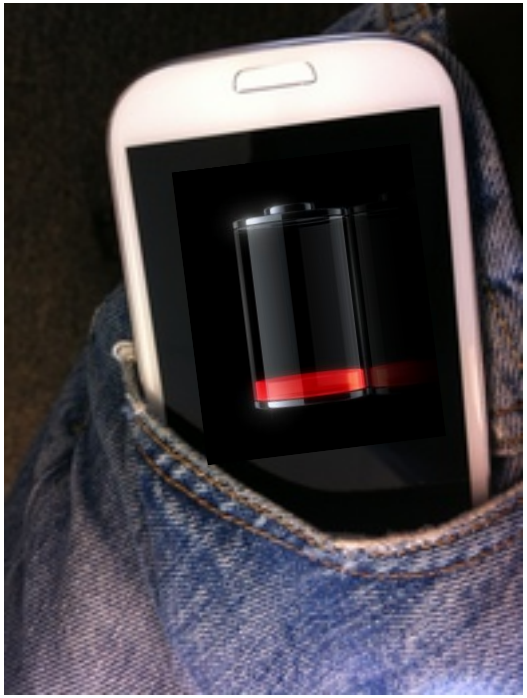
[1]University of Michigan [2]AT&T Labs - Research

# Screen-off traffic characterization: an interesting yet unexplored topic

- Smartphone screen is switched on and off often (>**50** times/day/user)
- Screen status is a good heuristic for determining whether the user is actively interacting with the device
- Battery is scarce resource for smartphones

# Screen-off traffic characterization: an interesting yet unexplored topic

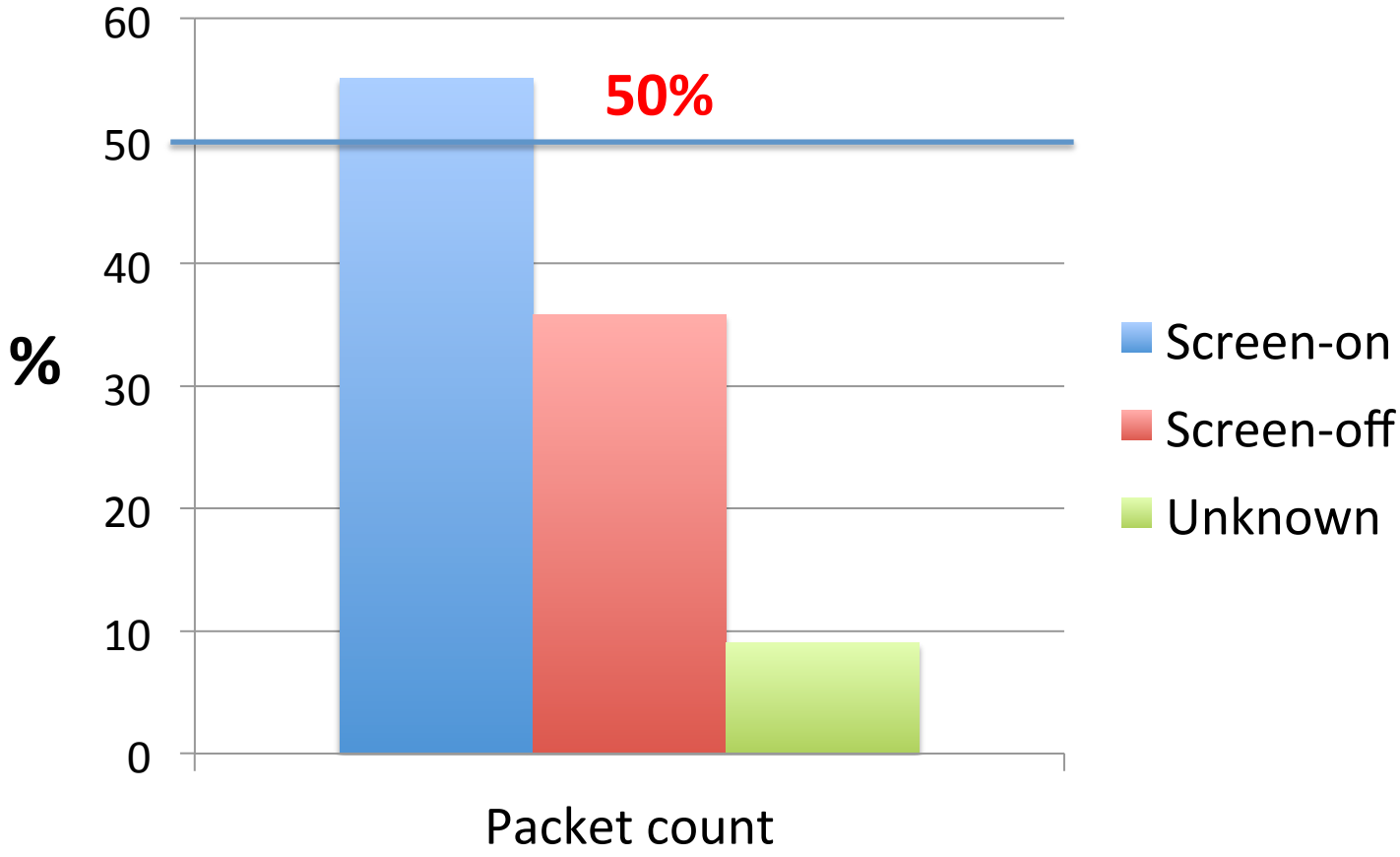
- Smartphone screen is switched on and off often (>**50** times/day/user)
- Screen status is a good heuristic for determining whether the user is actively interacting with the device
- Battery is scarce resource for smartphones



# Data set studied

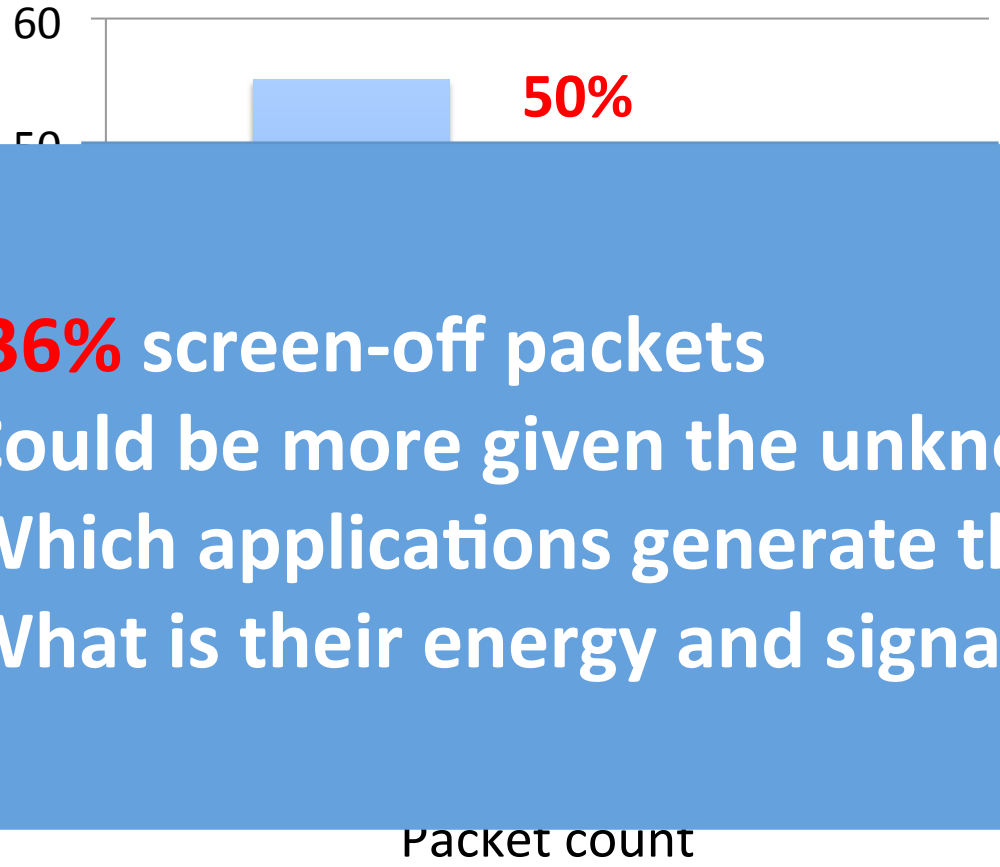
- Collected from **20** volunteers in **5** months
  - May 2011 ~ Oct 2011, Android 2.2 smartphones
- Full packet payload and process association is collected
  - **131.49** millions packets
  - **80.03GB** payload
- Screen on/off status with sampling rate of ***1Hz***

# Breakdown of packet count based on screen status




*Unknown group: 9% of all packets, due to users accidentally terminating screen status logger*

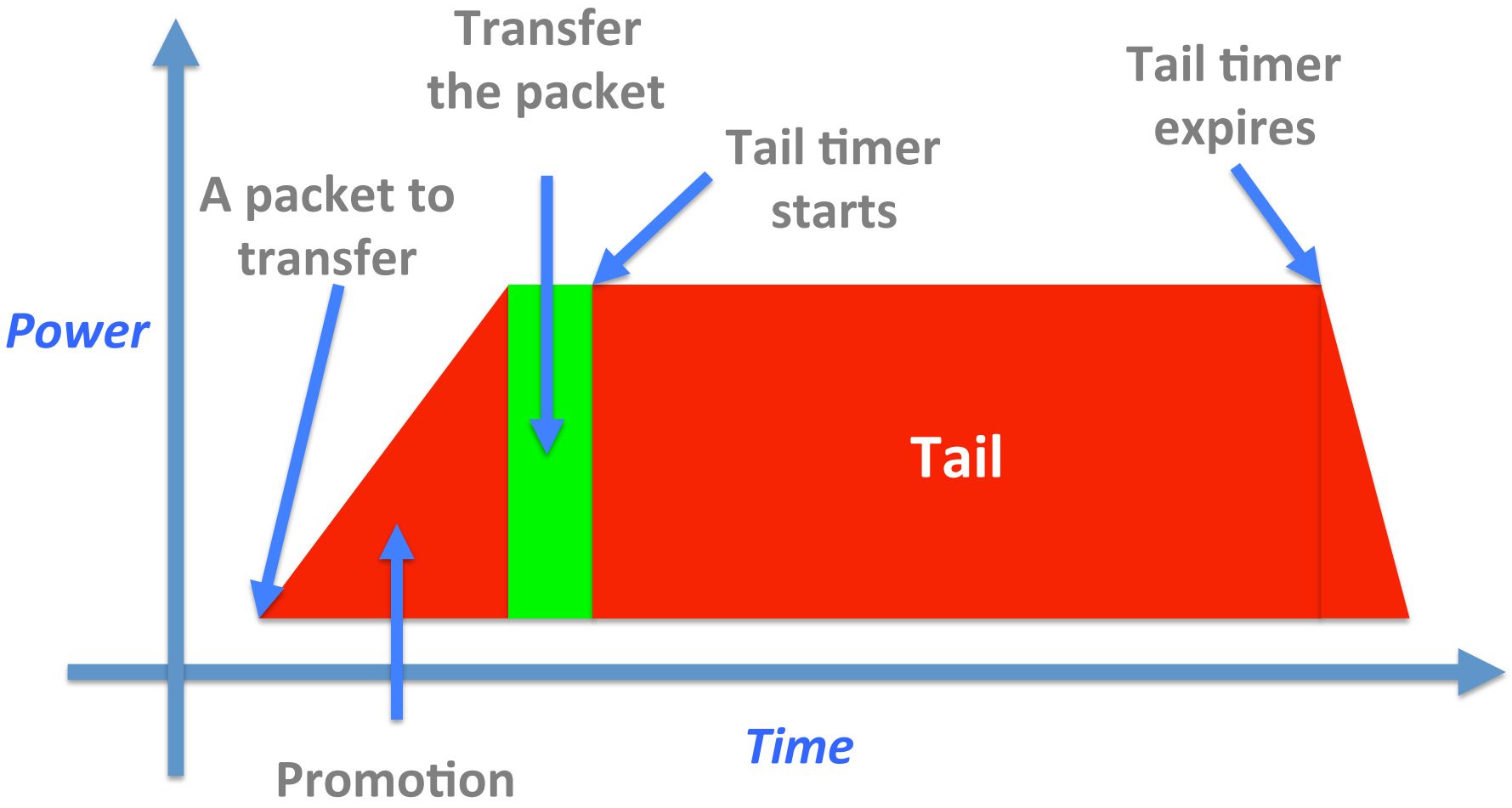
# Breakdown of packet count based on screen status




- **36% screen-off packets**
- **Could be more given the unknown category**
- **Which applications generate them?**
- **What is their energy and signaling impact?**

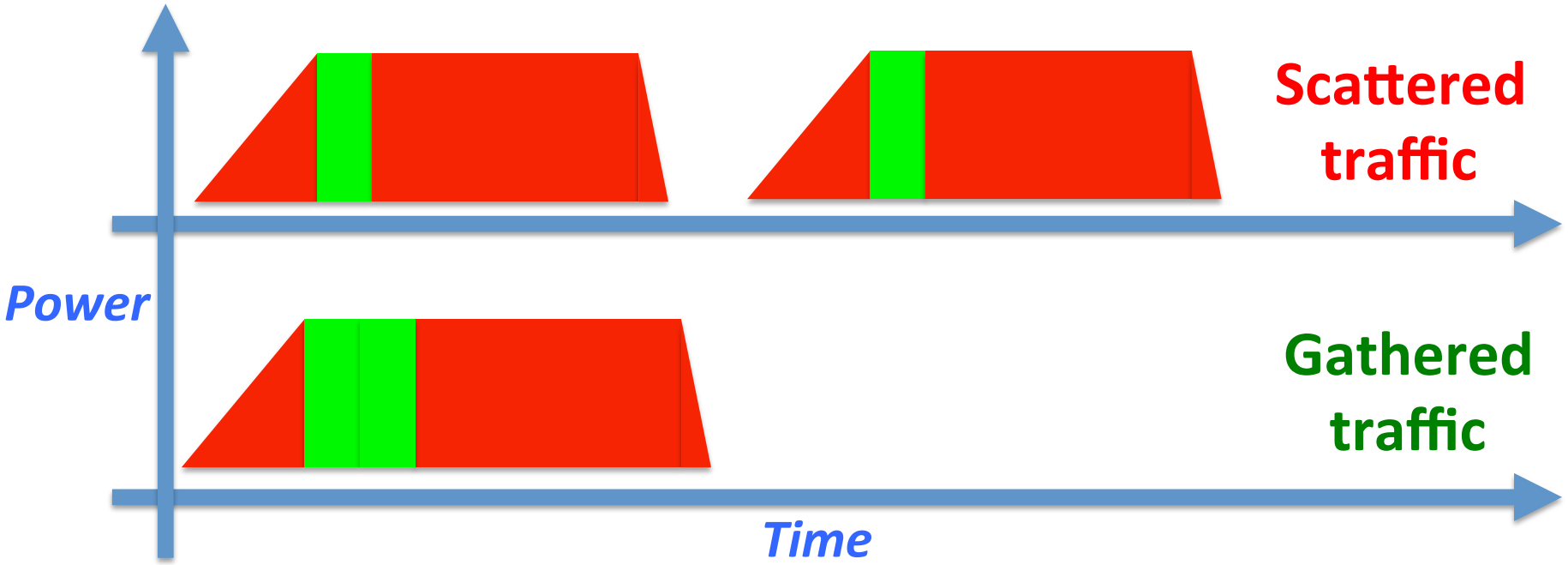
*Unknown group: 9.02% of all packets, due to users accidentally terminating screen status logger*

# Radio Resource Control (RRC) state machine



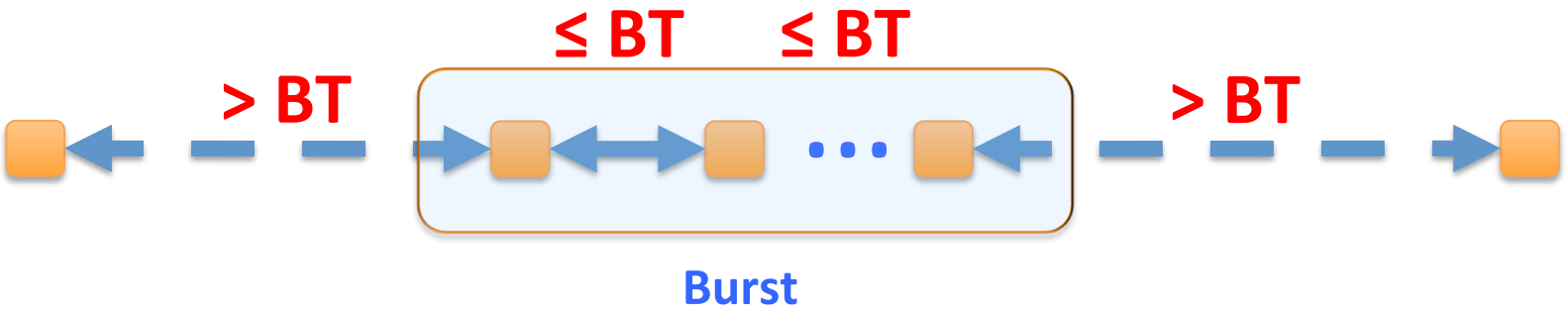
# How does traffic pattern affect energy and radio resource?

- **Scattered** traffic consumes more energy and radio resource than **Gathered** traffic



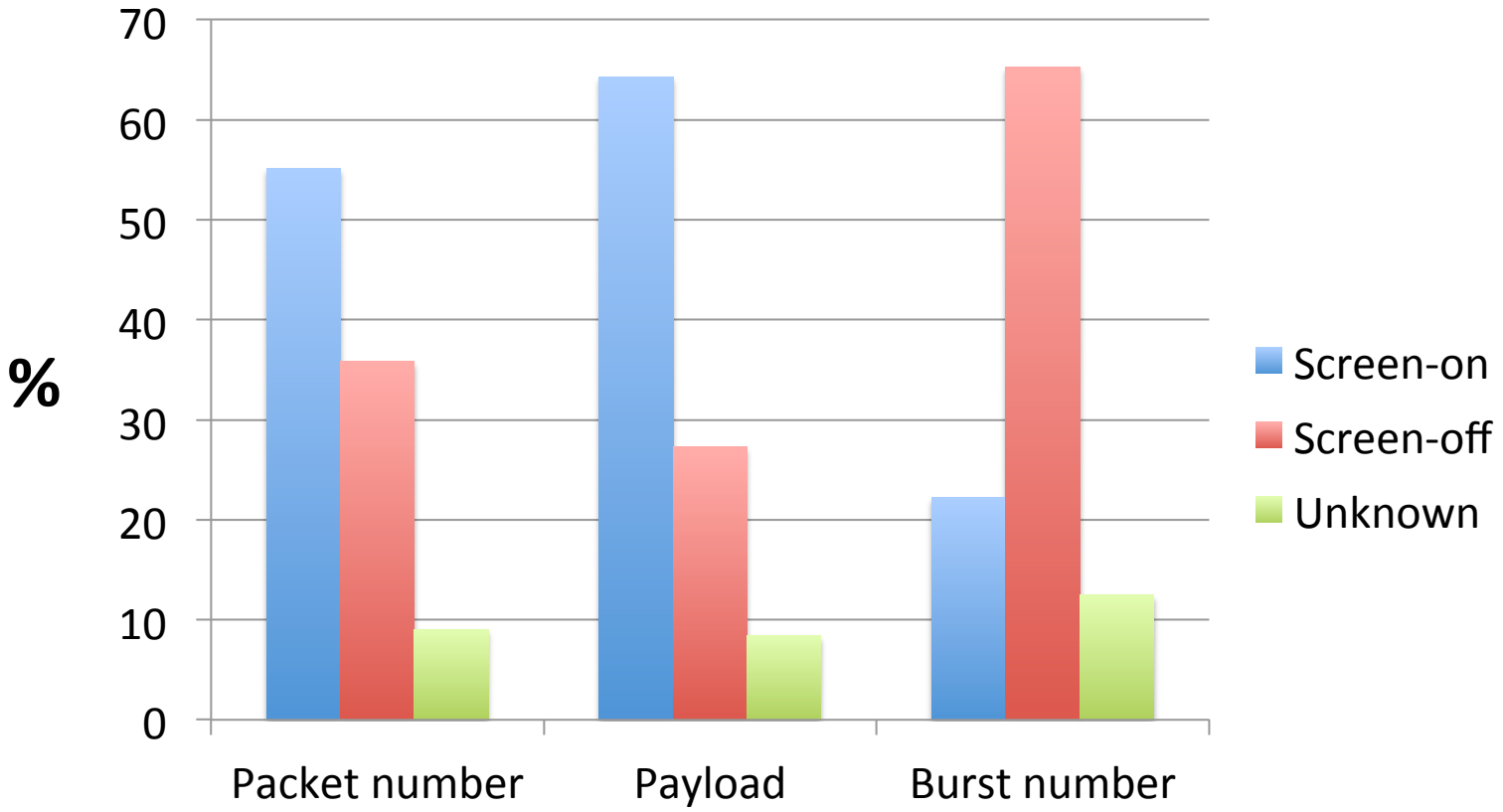
# Definition of a "***burst***"

- A burst is a sequence of packets with inter-packet time ≤ **BT**, and leading/trailing gap > **BT**
- **BT** is burst threshold selected empirically based on network RTTs, e.g. BT = 2s



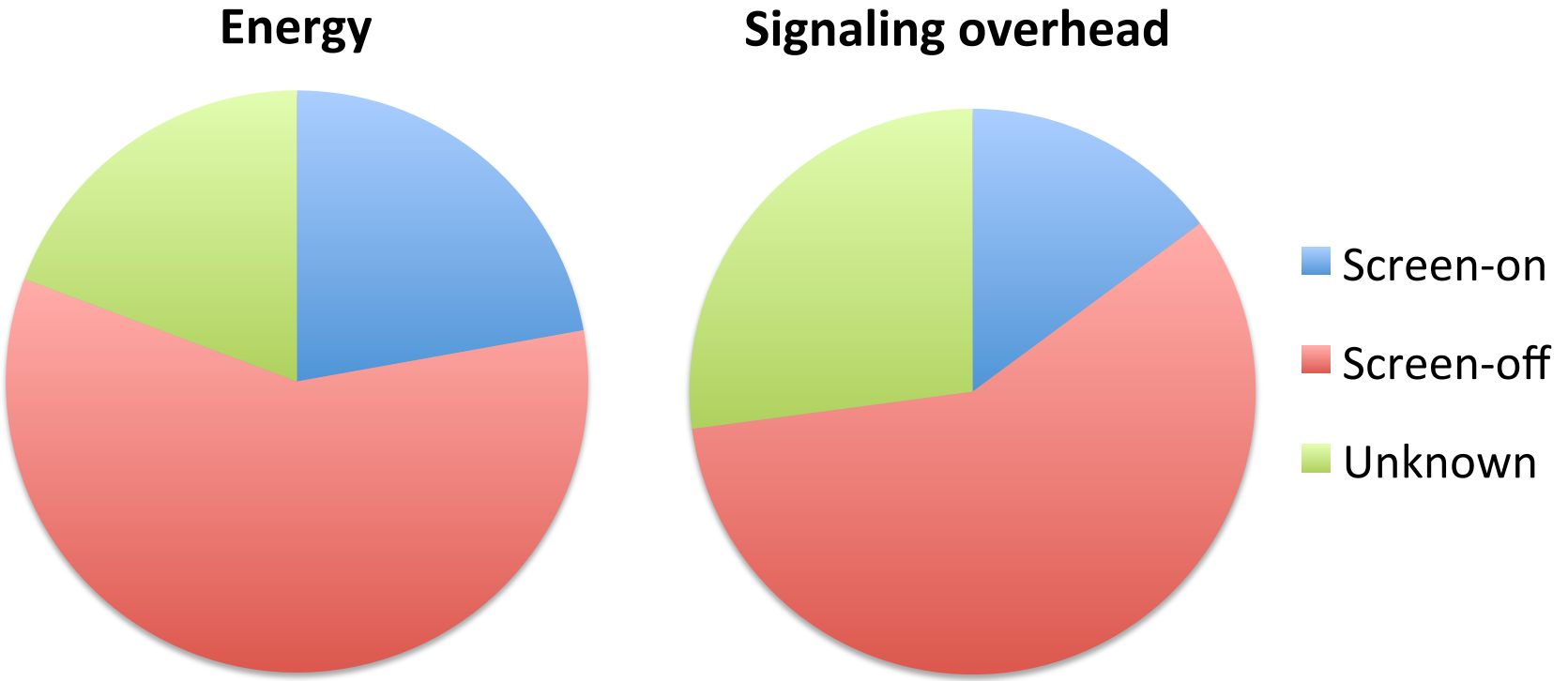
# Screen-on and screen-off traffic comparison

- Screen-off traffic has **less** packets/payload, but **more** bursts which are **smaller** and **shorter**



# Does screen-off traffic matter for radio resource and energy?

- Yes! Actually, screen-off traffic has higher impact than screen-on, though with less packets



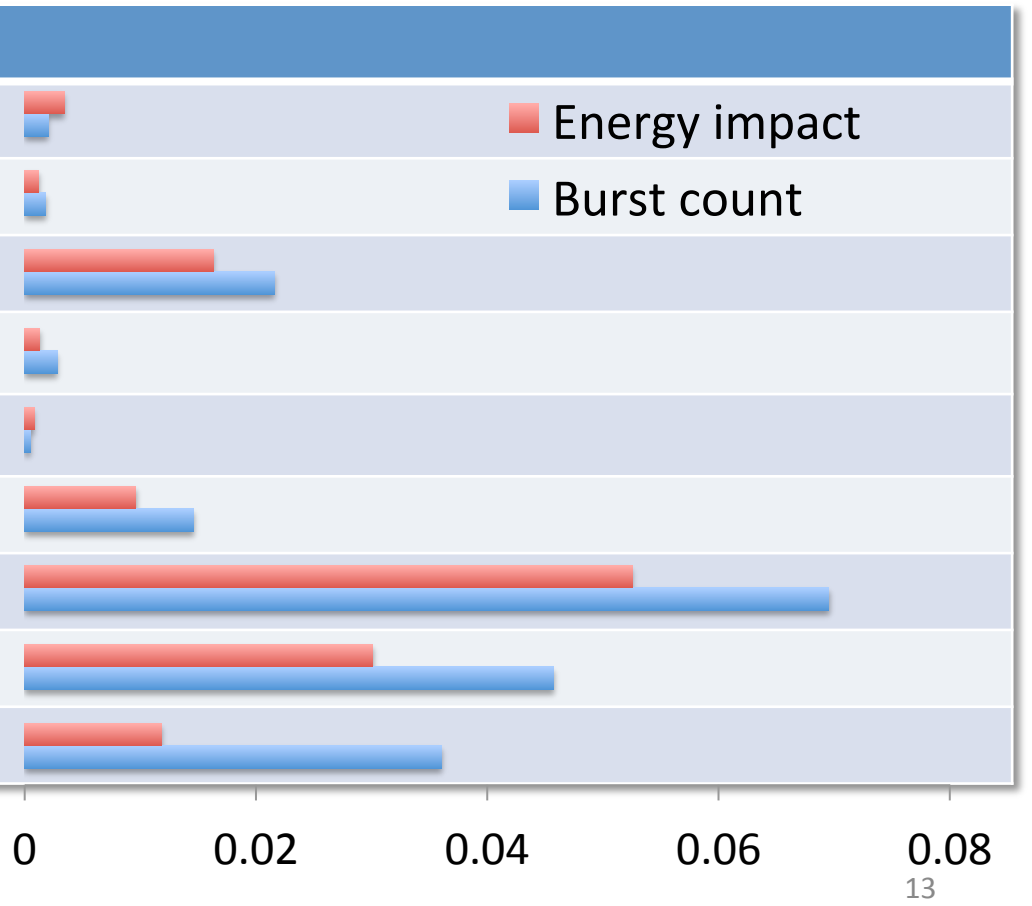
# Top screen-off applications based on packet count

| Application category | screen-off packets / total packets |
|---|---|
| Homescreen widget | 3.80% |
| Multimedia streaming | 3.30% |
| Utility | 2.69% |
| Multimedia streaming | 2.66% |
| Multimedia streaming | 2.37% |
| Utility | 2.07% |
| Social network | 1.95% |
| News | 1.94% |
| Email | 1.33% |

# Energy impact of top screen-off applications

- **Scattered** group has more bursts than **Gathered** group, incurring higher energy impact

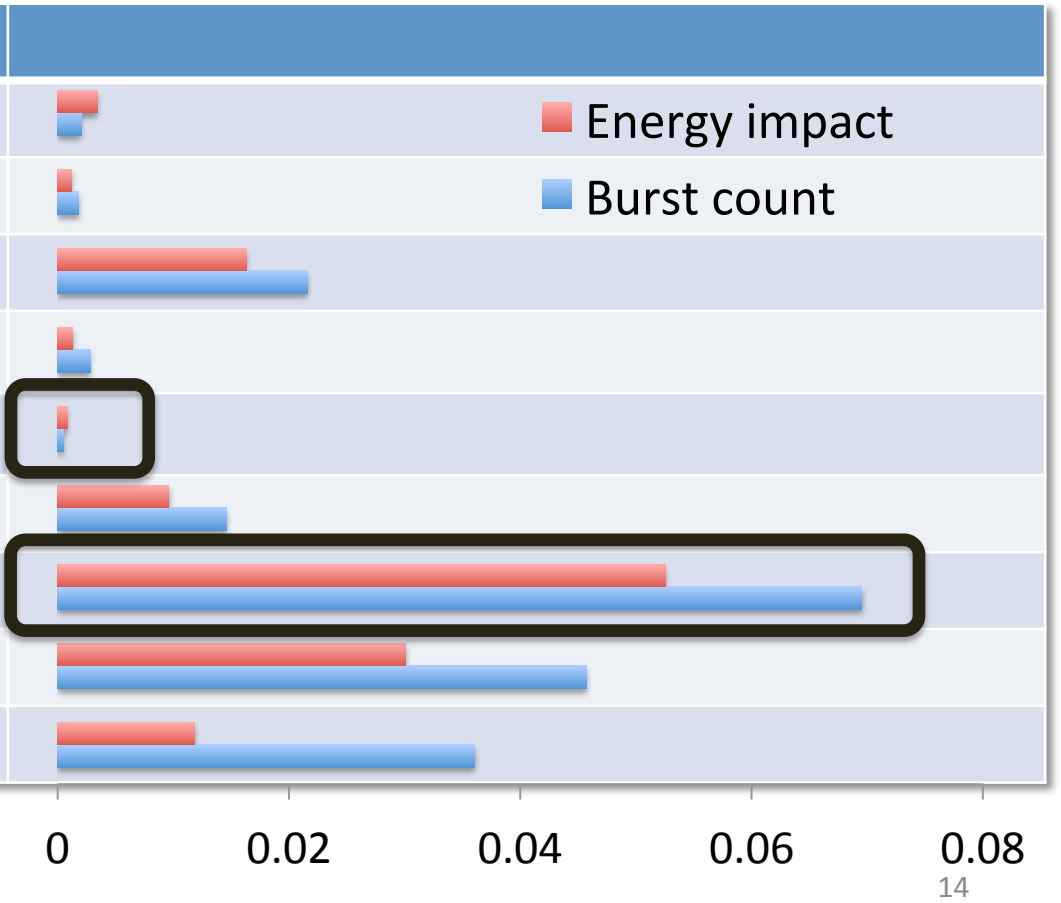
| Application category | Group |
|---|---|
| Homescreen widget | Gathered |
| Multimedia streaming | Gathered |
| Utility | Scattered |
| Multimedia streaming | Gathered |
| Multimedia streaming | Gathered |
| Utility | Scattered |
| Social network | Scattered |
| News | Scattered |
| Email | Scattered |



# Energy impact of top screen-off applications

- **Scattered** group has more bursts than **Gathered** group, incurring higher energy impact

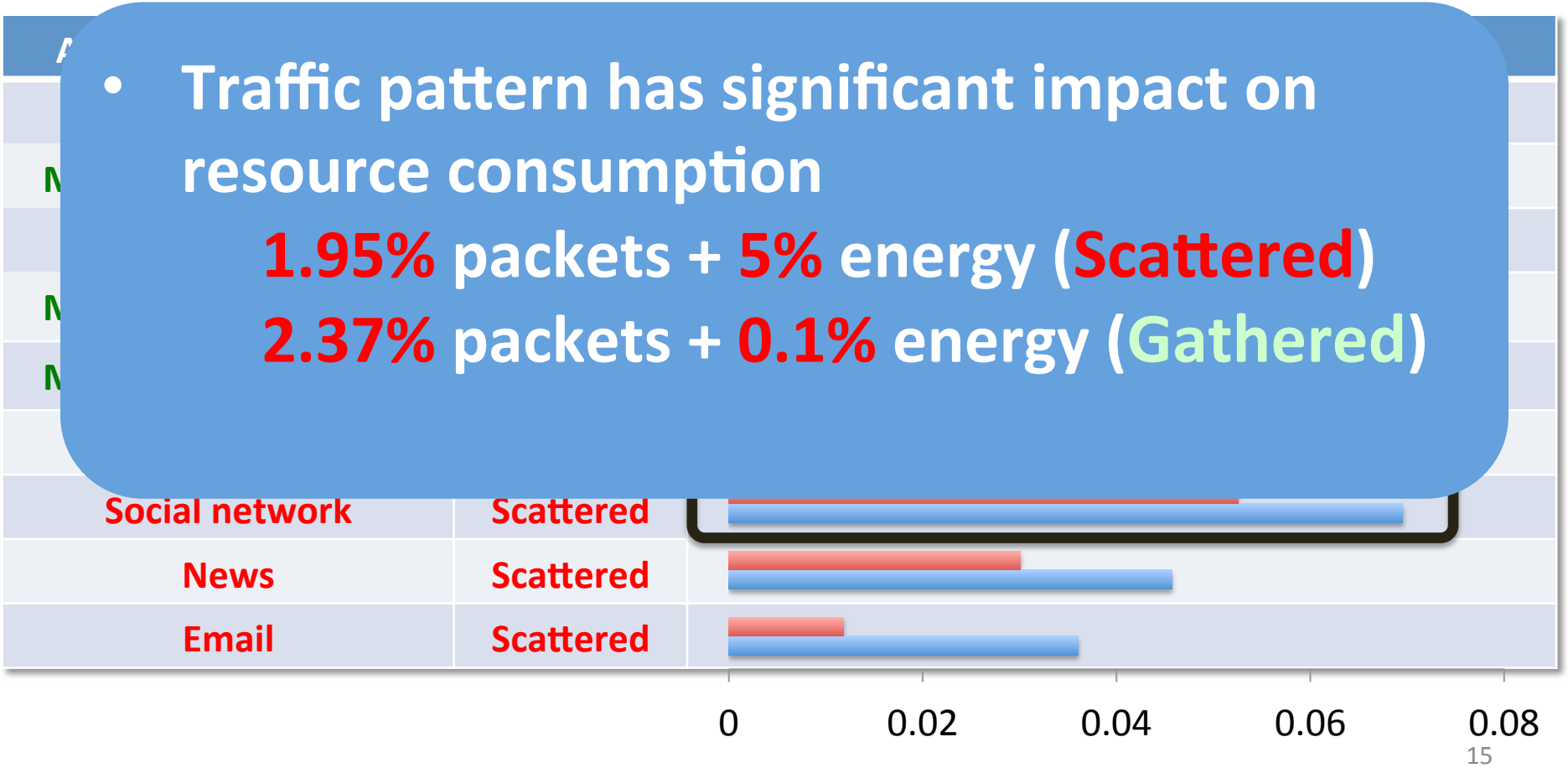
| Application category | Group |
|---|---|
| Homescreen widget | Gathered |
| Multimedia streaming | Gathered |
| Utility | Scattered |
| Multimedia streaming | Gathered |
| Multimedia streaming | Gathered |
| Utility | Scattered |
| Social network | Scattered |
| News | Scattered |
| Email | Scattered |



# Energy impact of top screen-off applications

- **Scattered** group has more bursts than **Gathered** group, incurring higher energy impact

- **Traffic pattern has significant impact on resource consumption**
  - **1.95%** packets + **5%** energy (**Scattered**)
  - **2.37%** packets + **0.1%** energy (**Gathered**)

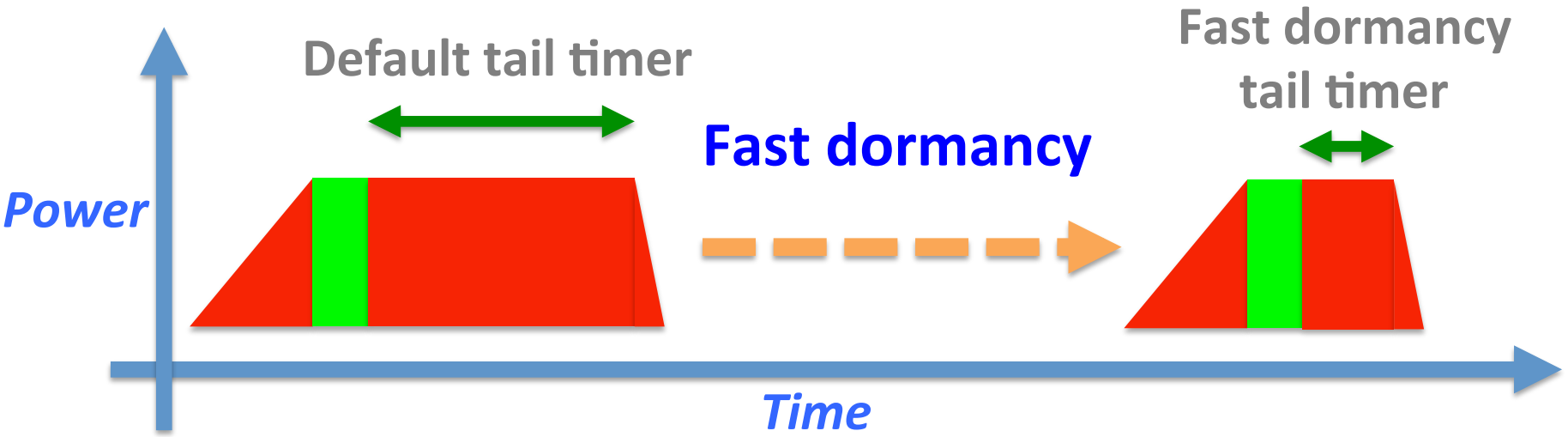


# Screen-aware traffic optimization

- Apply more aggressive settings to screen-off traffic
  - Reason 1: high energy and signaling impact
  - Reason 2: traffic pattern is more “scattered”
  - Reason 3: less user interaction and more tolerance in delay

# Case study: screen-aware fast dormancy

- Fast dormancy reduces the tail length by actively notifying the network for early demotion



# Case study: screen-aware fast dormancy

- Fast dormancy reduces the tail length by actively notifying the network for early

- **Screen-aware fast dormancy: a shorter tail timer for screen-off traffic**
- **For the same signaling overhead, screen-aware fast dormancy increases energy saving by 15% compared with basic fast dormancy**

*Pov*

# Summary

- Screen-off traffic incurs more energy overhead, with fewer packets and less payload than screen-on traffic
- Screen-aware optimization improves the resource efficiency and is simple to implement
- Other screen-aware traffic optimization techniques studied in the paper, e.g., batching



# Thank you!

## Q & A

Contact: Junxian Huang (hjx@umich.edu)