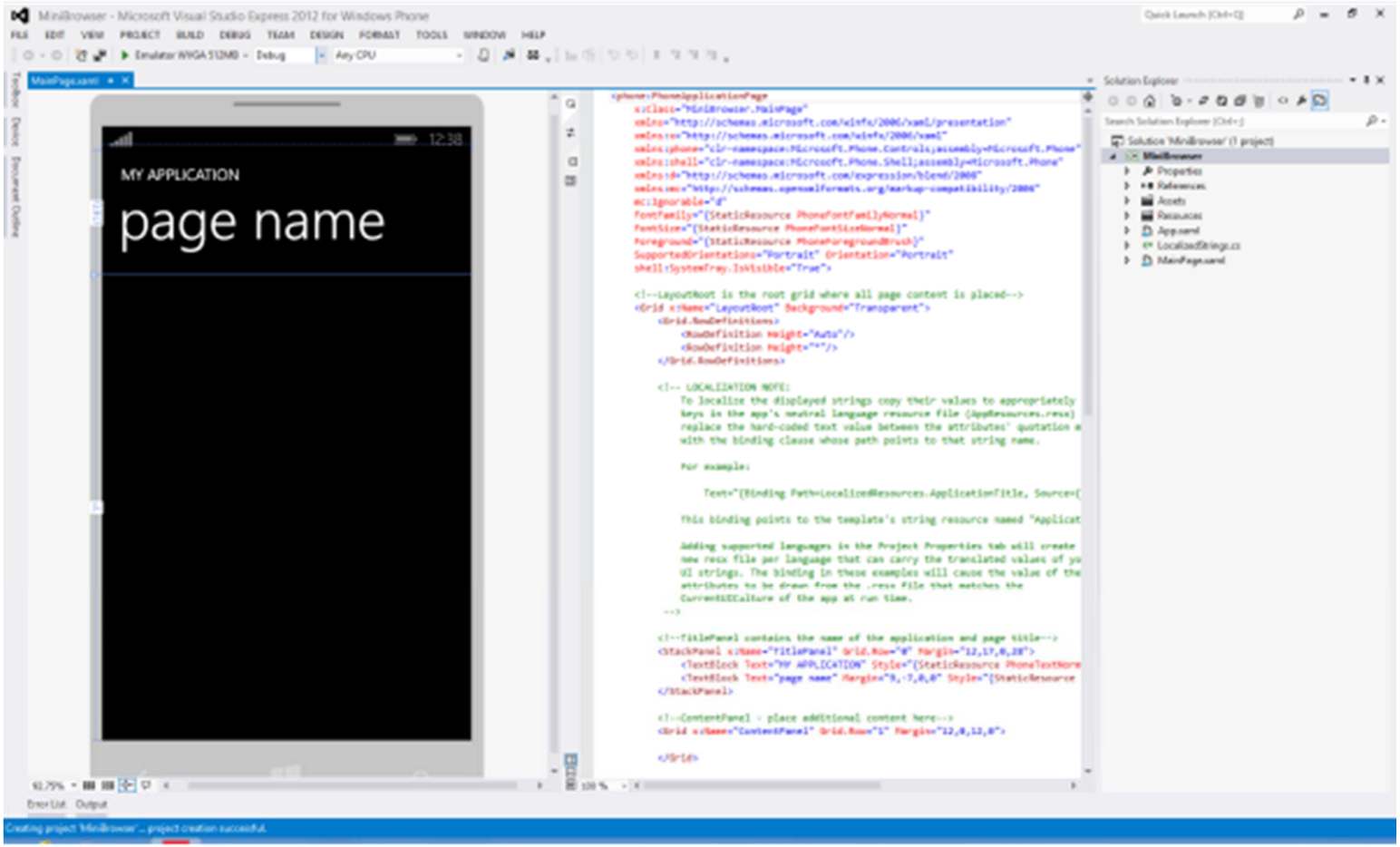
mobile measurements: the mobile app / OS perspective

Why understanding mobile app performance is hard

cellular performance matters to some apps

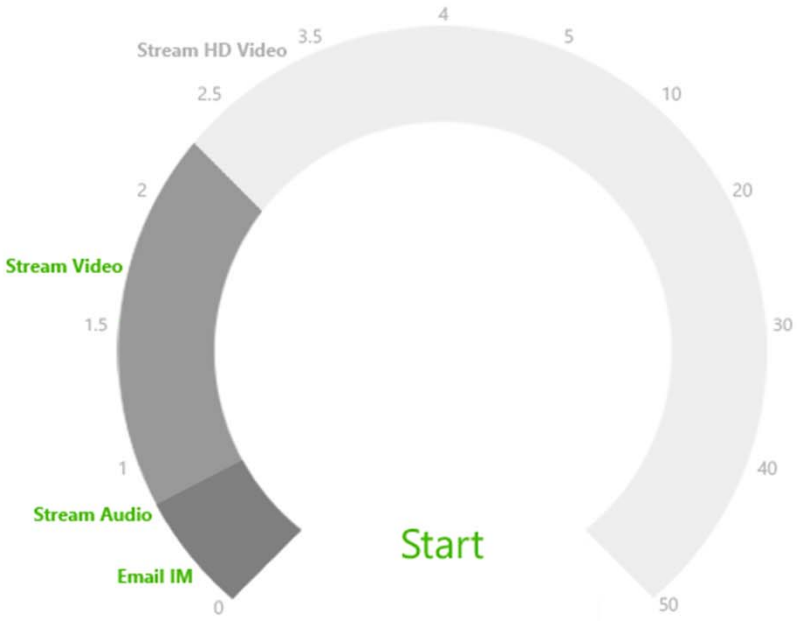
- most demanding apps
  - multiplayer gaming
  - VoIP
  - video chat
- somewhat demanding
  - web search
  - app interfaces with web services
- reasonably irrelevant
  - network transfers that aren't in the critical path

app development environment



Network Speed Test

Last Test on A-MSFTWLAN



Network Delay
76 ms

Download speed
2.3 Mbps

Upload speed
0.7 Mbps

Current Network

Connection
WiFi

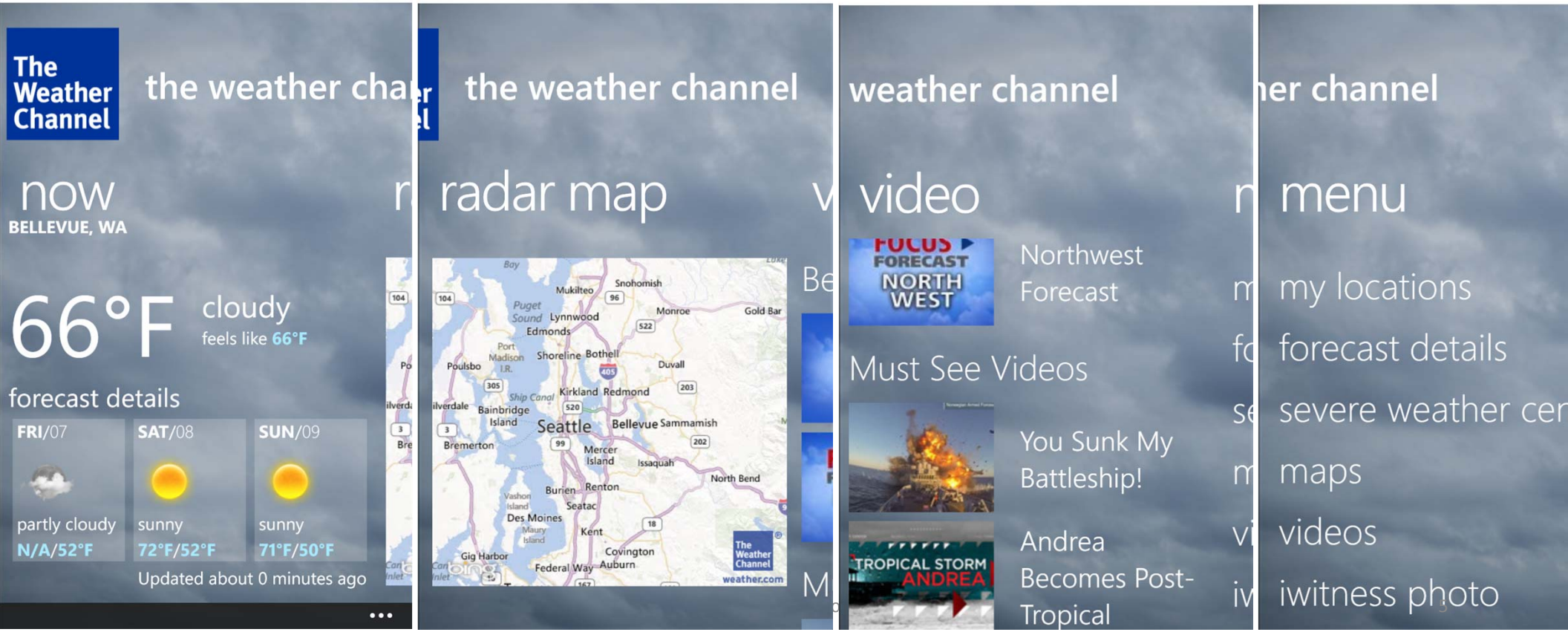
Network Name
A-MSFTWLAN

Internet
Connected

History

A-MSFTWLAN (Wi-Fi)
08/30/12
Latency: 76ms Download: 21Mbps Upload: 0.5

The Weather Channel




htc
Mitt
Rating


htc
Mitt
Rating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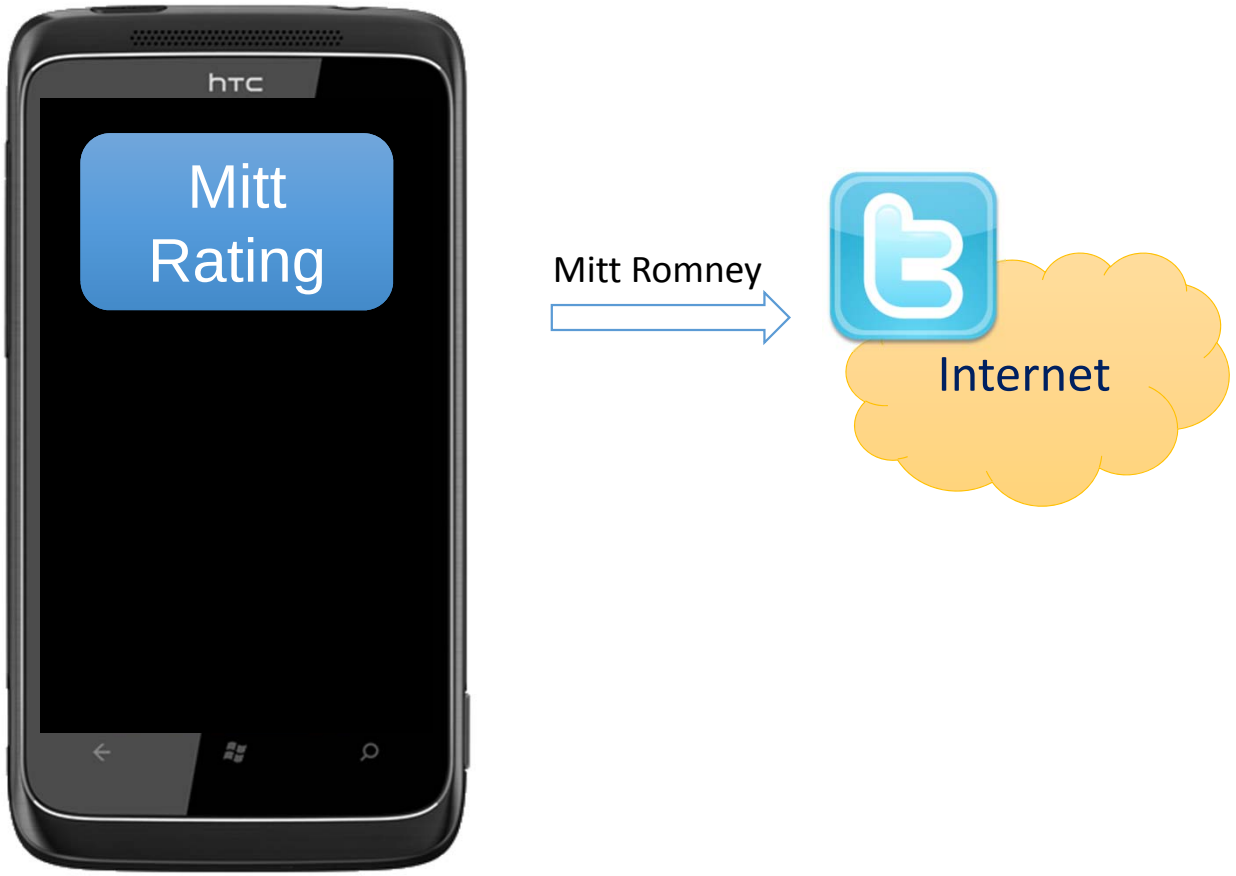
Mitt
Rating


htc
Mitt
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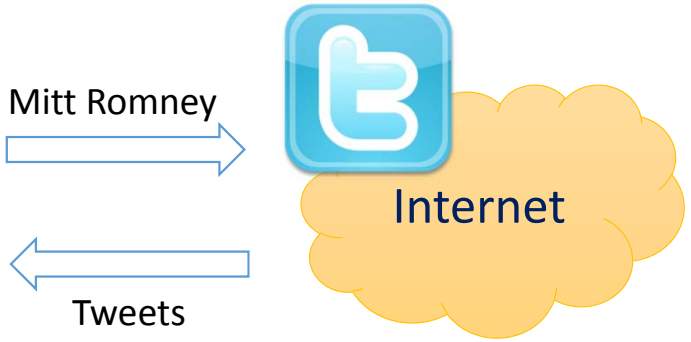
Mitt Romney
Internet

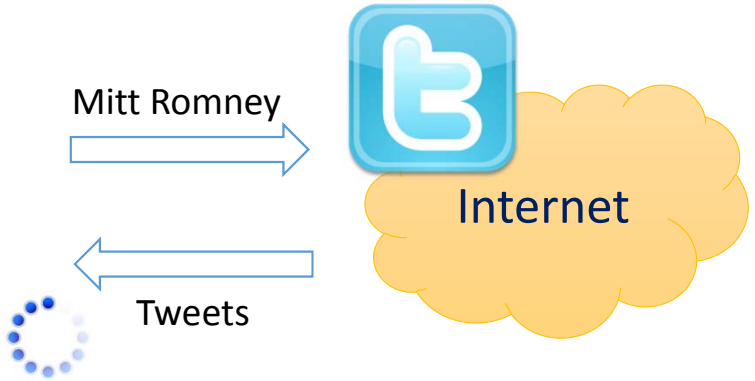


"If I had a nickel for every time Mitt Romney said something stupid I'd be in his tax bracket"

"Mitt Romney might vote for Obama as well"

"We recommend Mitt Romney for president"

"I would definitely trust **Mitt Romney** with my money."



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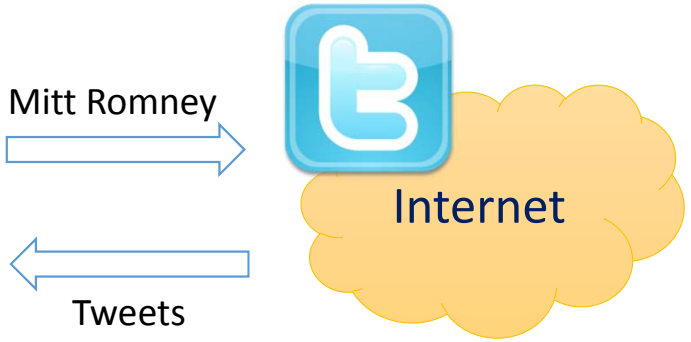

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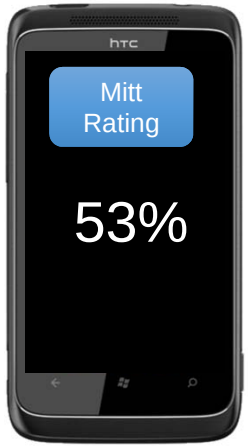
Hypothetical Synchronous Code

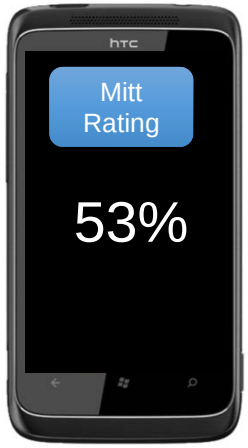


Hypothetical Synchronous Code

```
ClickHandler()
{




}
```



Hypothetical Synchronous Code

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ClickHandler()
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    tweets = HttpGet(url);



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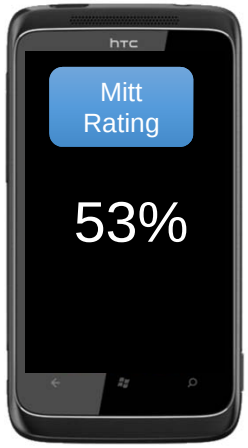
```



Hypothetical Synchronous Code

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ClickHandler()
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    tweets = HttpGet(url);
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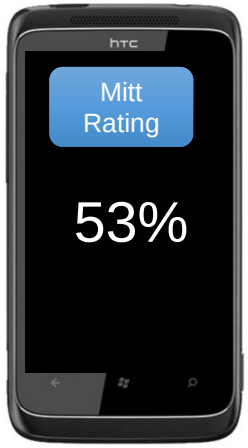
}

ProcessTweets(tweets)
{
    ...
}
```



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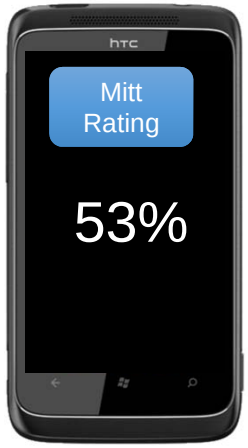

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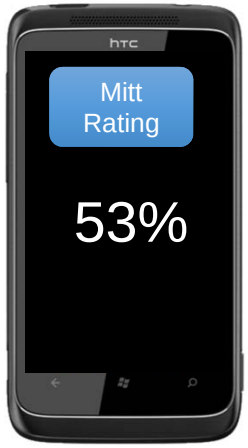

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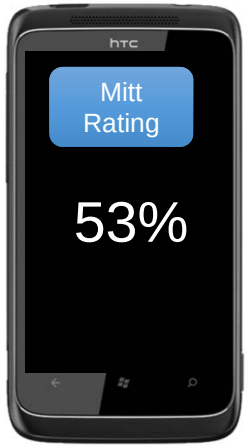
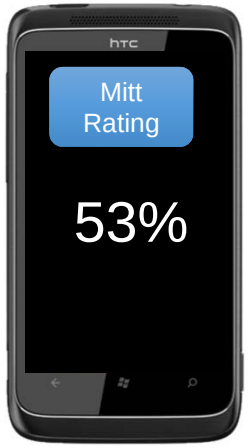


Asynchronous Code



Asynchronous Code

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ClickHandler()
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    rating = ProcessTweets(tweets);
    UIDispatch(DisplayRating, rating);
}
DisplayRating(rating)
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}
ProcessTweets(tweets)
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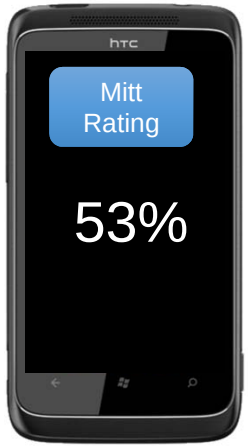
    ...
}
```



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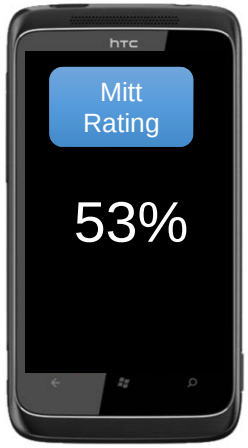

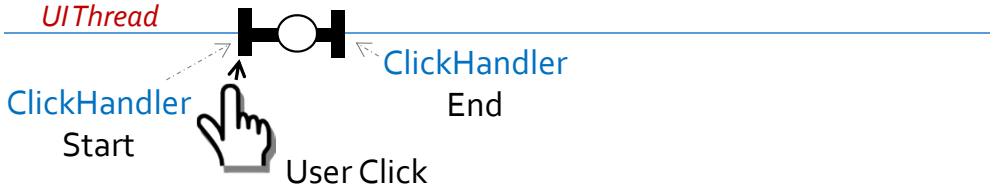

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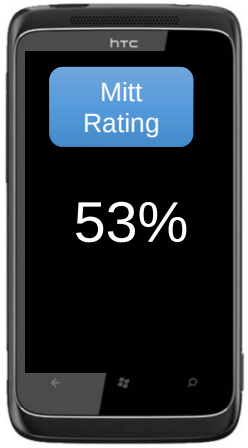

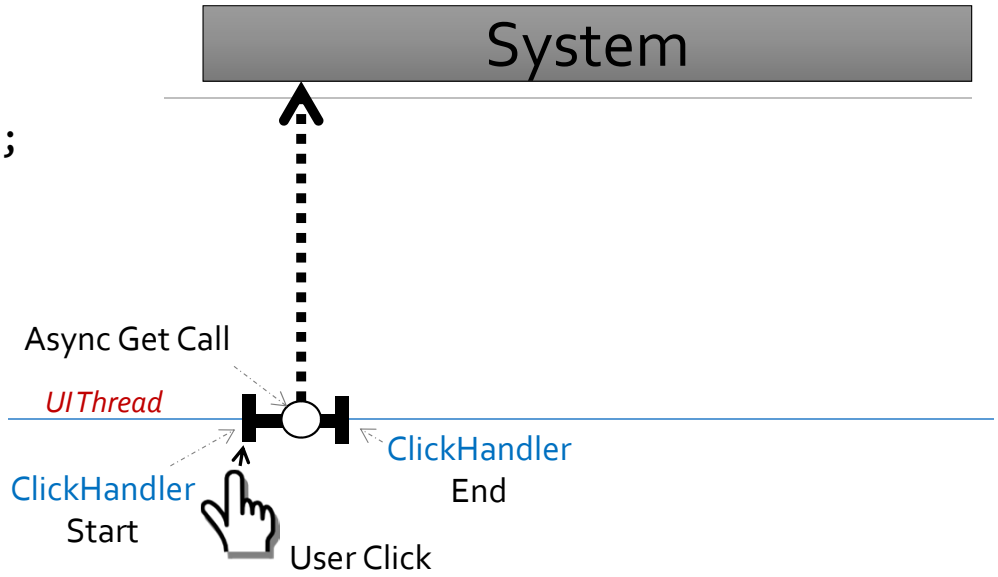

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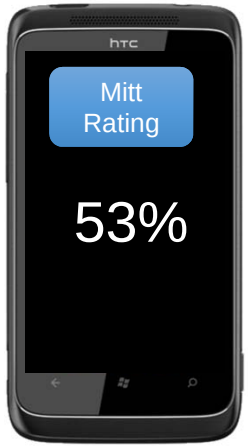

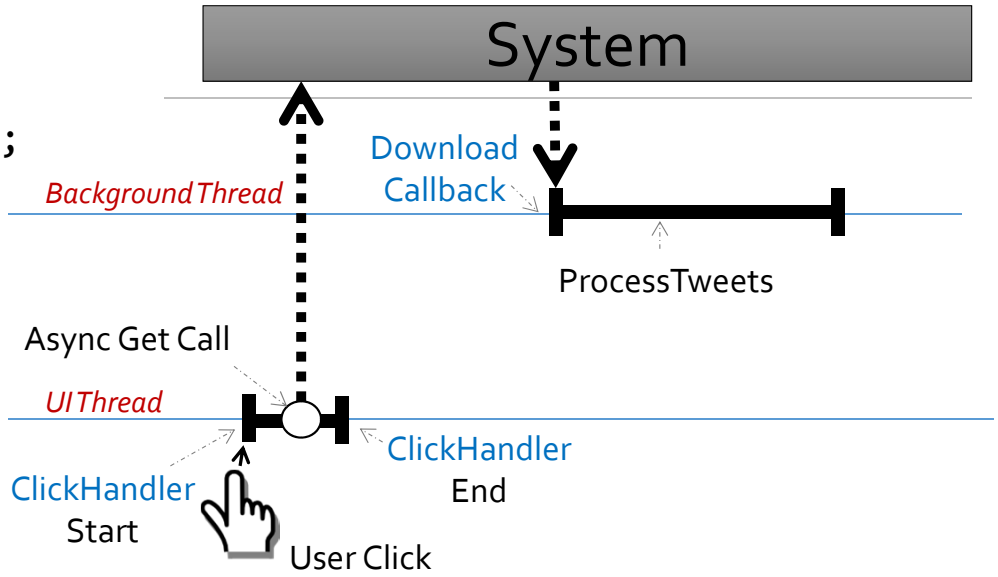

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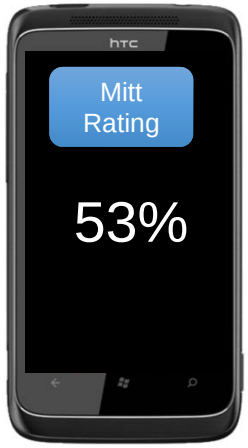

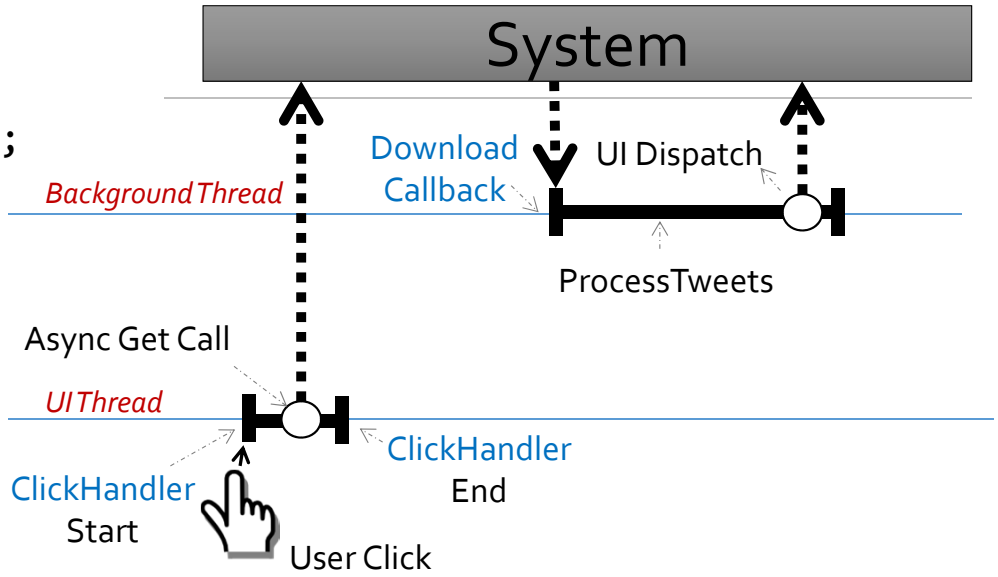

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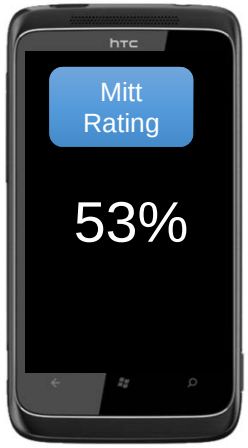
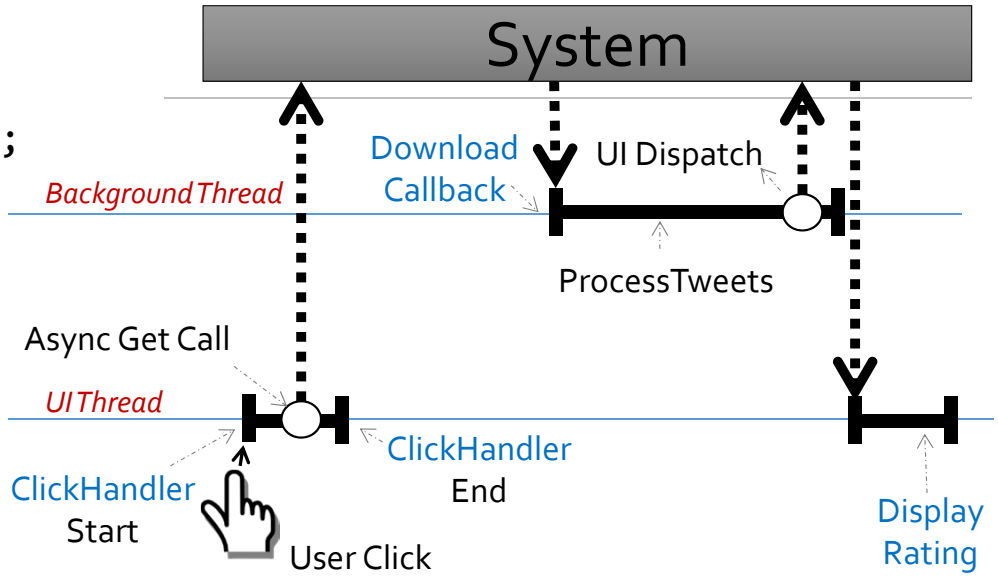
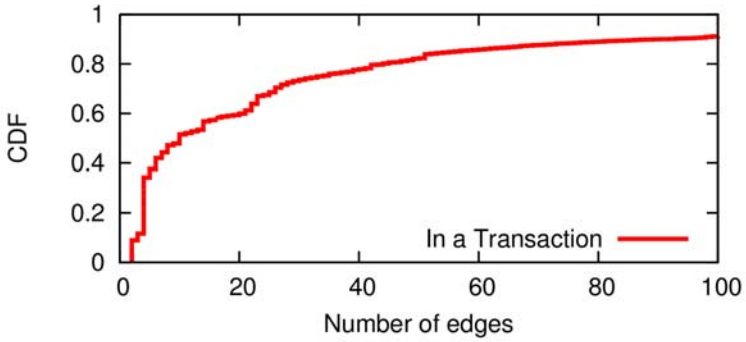


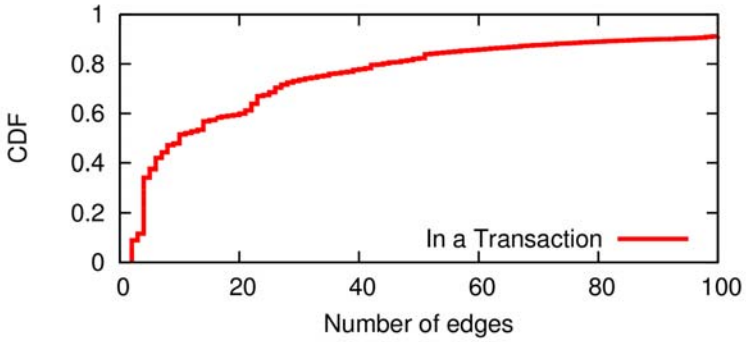


Apps are highly asynchronous



30 popular apps
167,000 transactions from user study

Apps are highly asynchronous



30 popular apps
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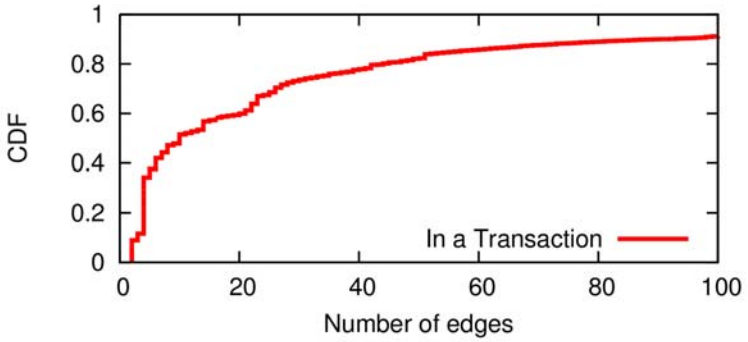
- On average, 19 asynchronous calls per user transaction
- On average, 8 parallel threads per user transaction

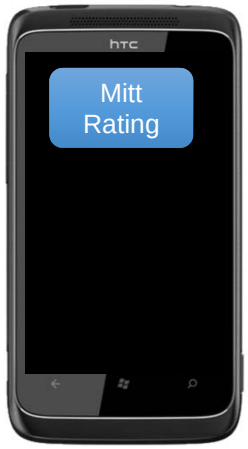
Apps are highly asynchronous

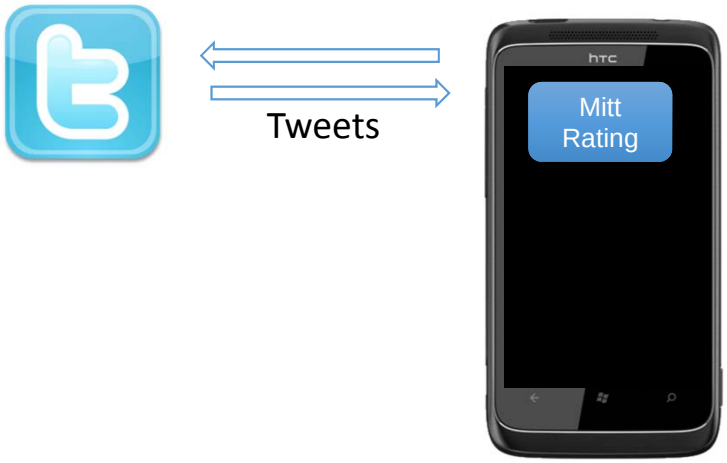


30 popular apps
167,000 transactions from user study

- On average, 19 asynchronous calls per user transaction
- On average, 8 parallel threads per user transaction

For each user transaction, what was the critical path, and did the network matter?


htc
Mitt
Rating


Tweets
htc
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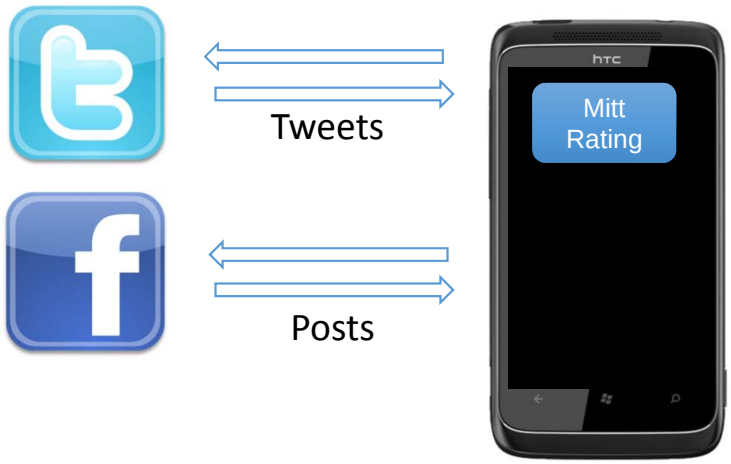
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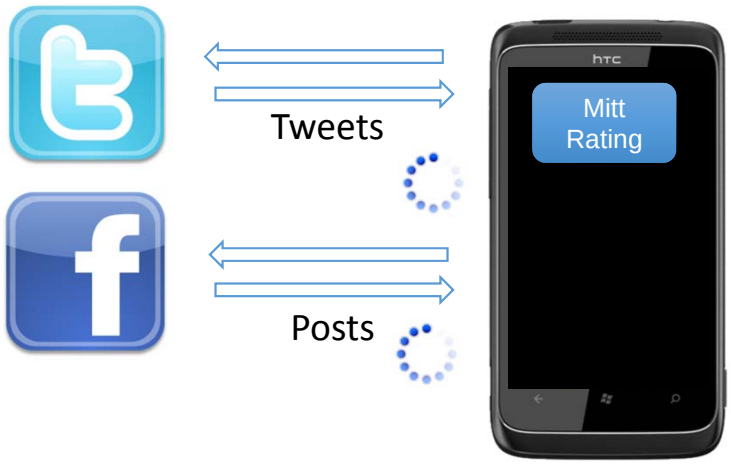
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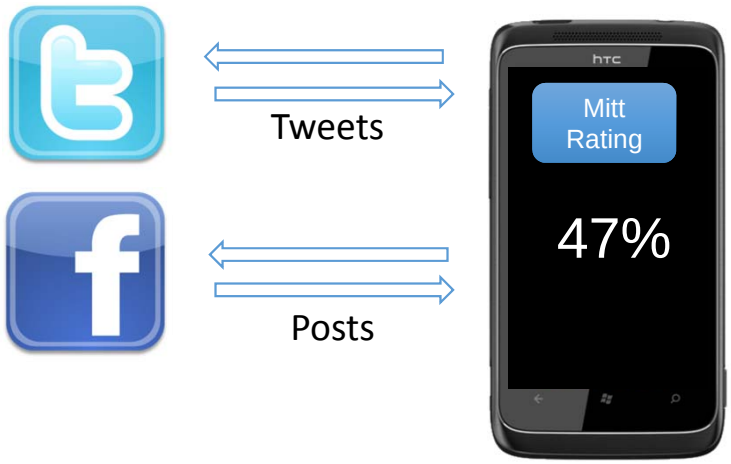
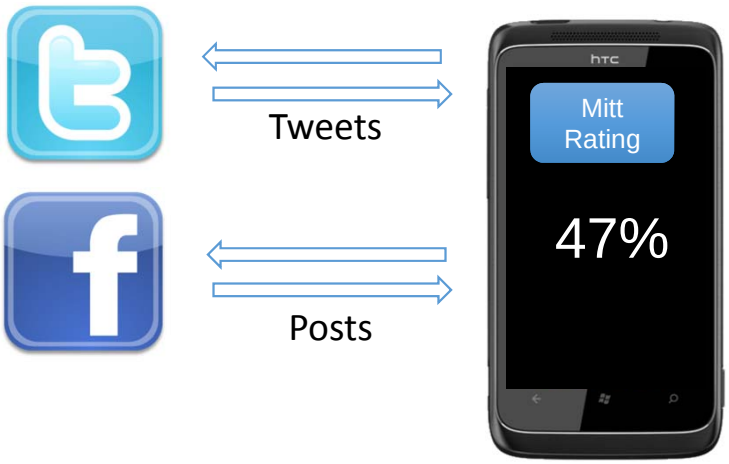

Tweets
Posts
htc
Mitt Rating
47%



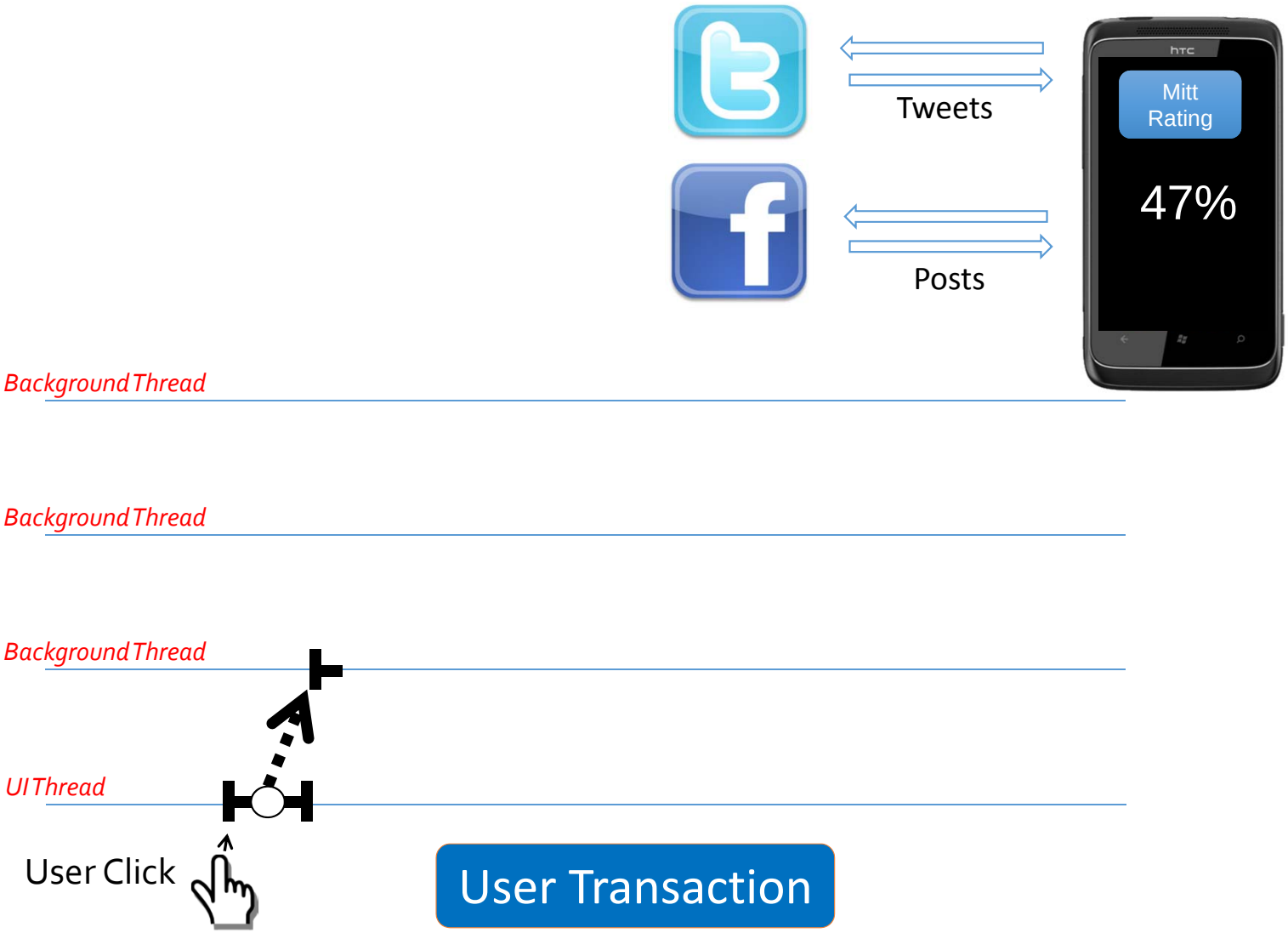
Background Thread

Background Thread

Background Thread

UI Thread

User Transaction


Tweets
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htc
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47%
Background Thread
Background Thread
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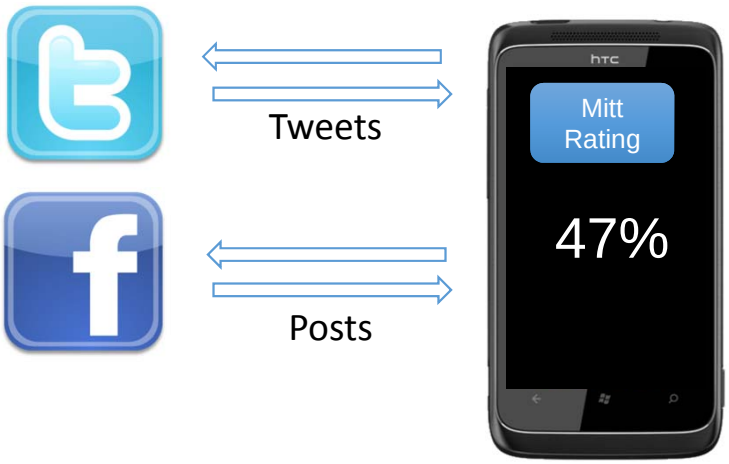
UI Thread
User Click
User Transaction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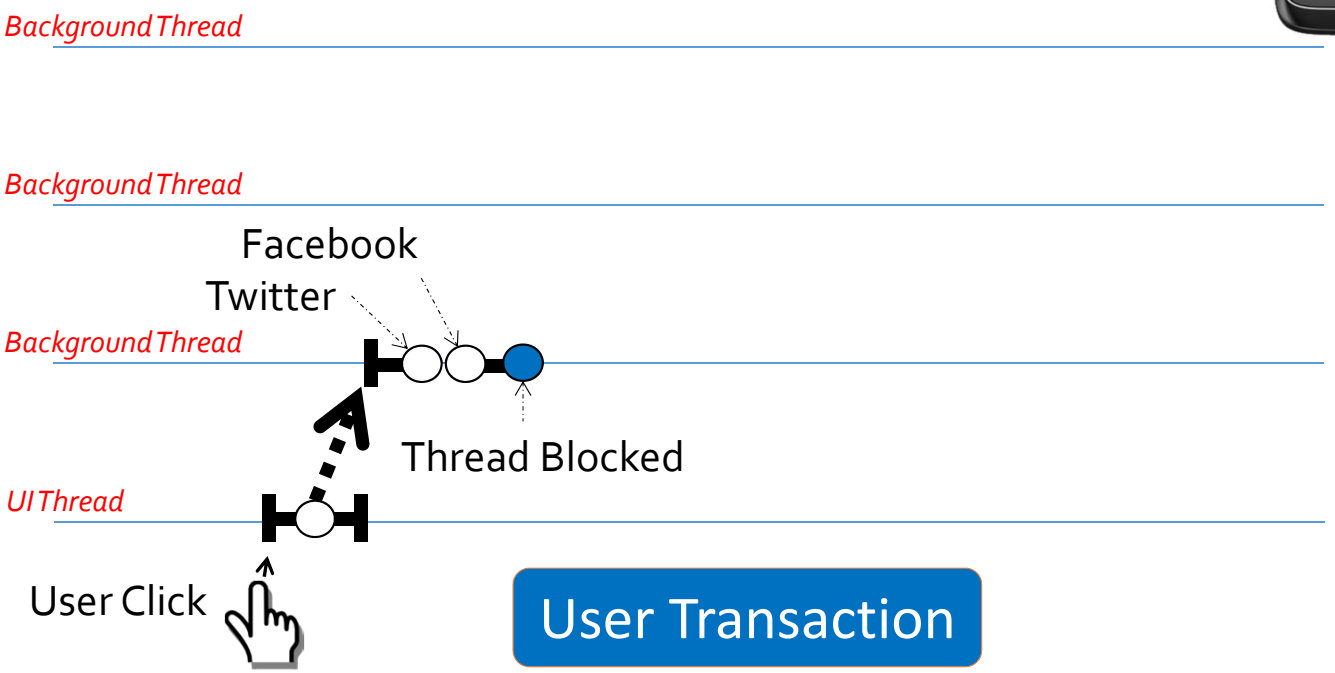
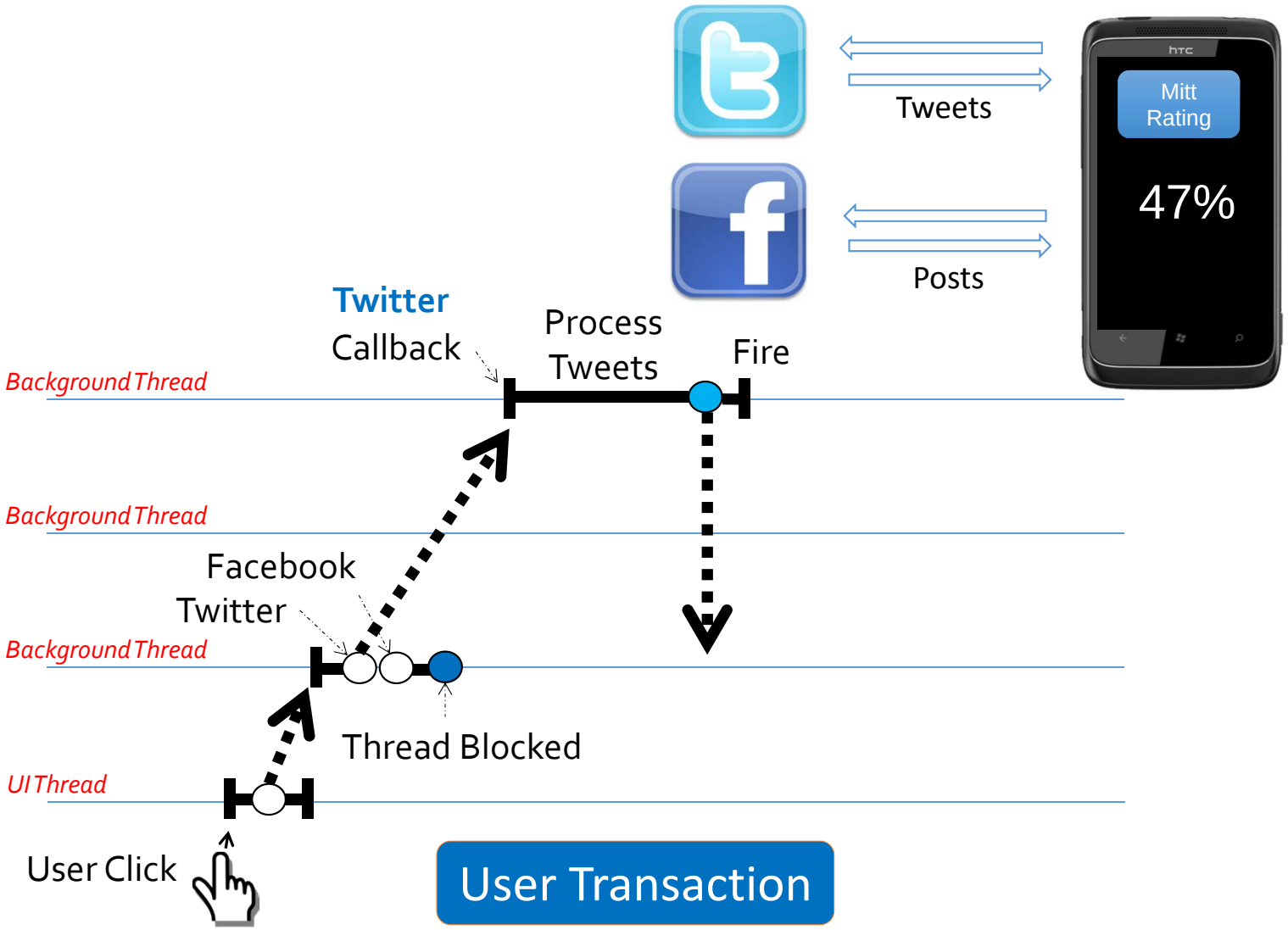

Background Thread
Background Thread
Facebook
Twitter
Background Thread
Thread Blocked
UI Thread
User Click
User Transaction


Tweets
Posts
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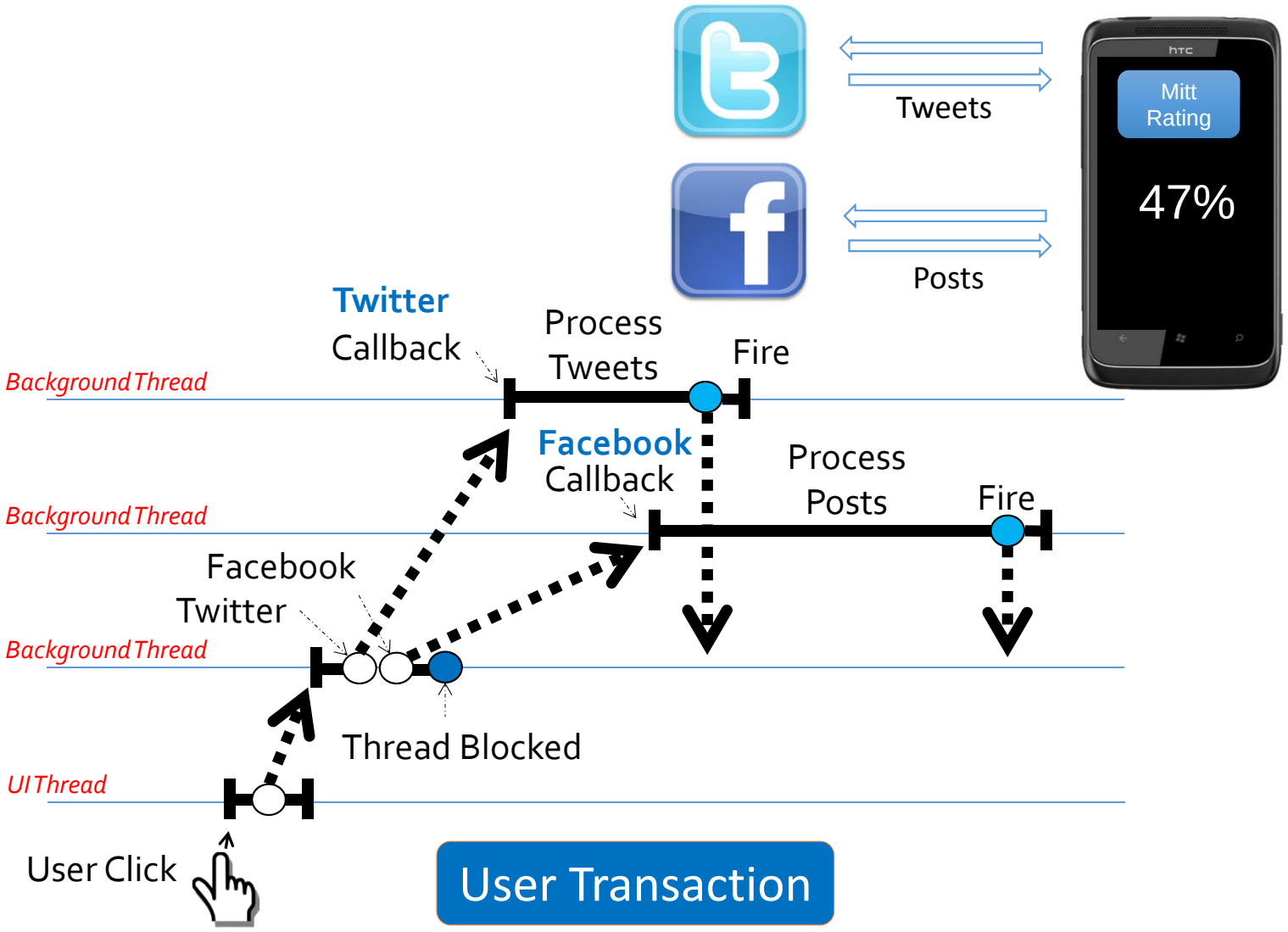
Twitter Callback
Process Tweets
Fire
Background Thread
Background Thread
Facebook
Twitter
Background Thread
Thread Blocked
UI Thread
User Click
User Transaction


Tweets
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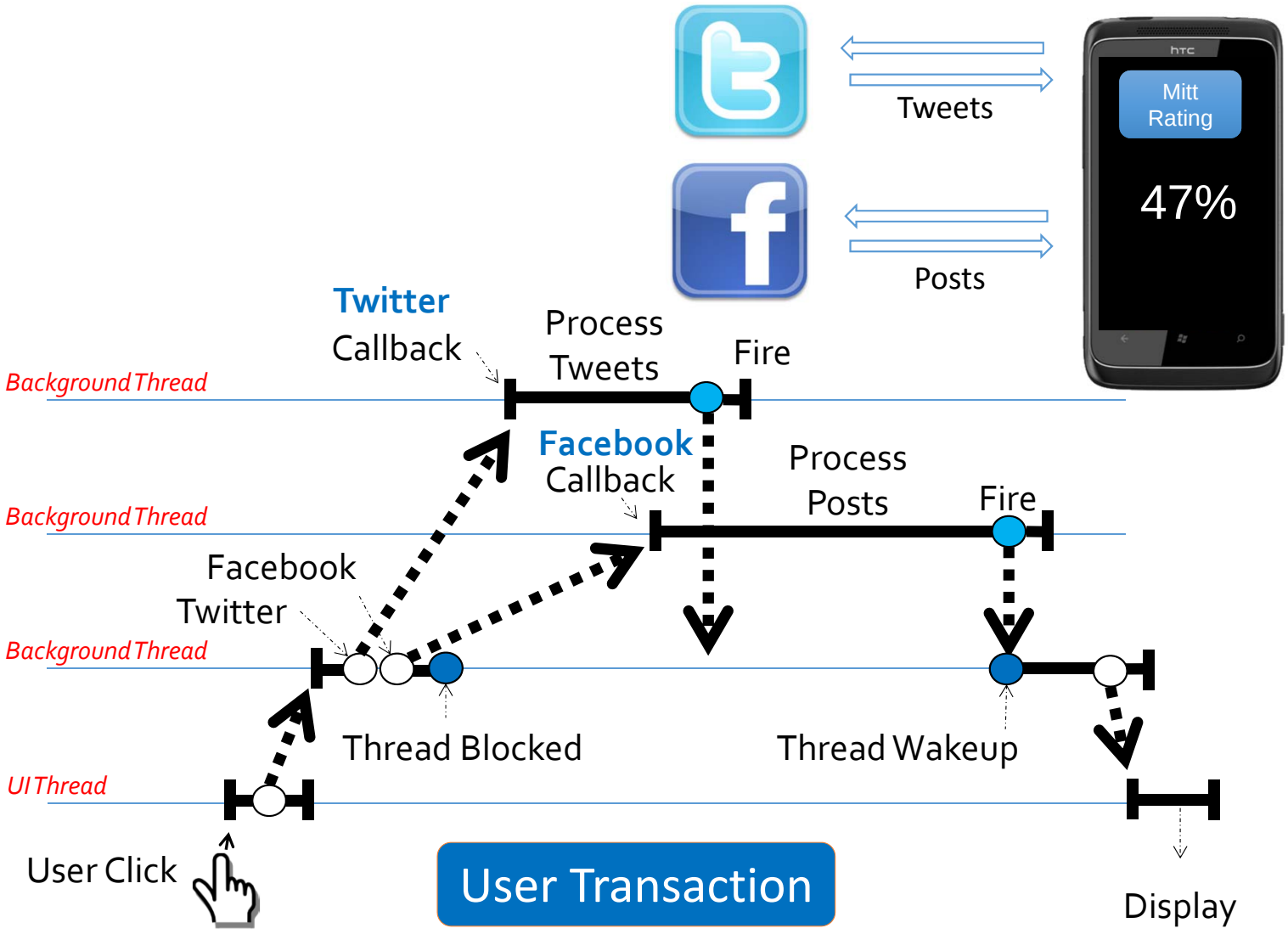
Tweets
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Twitter Callback
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Background Thread
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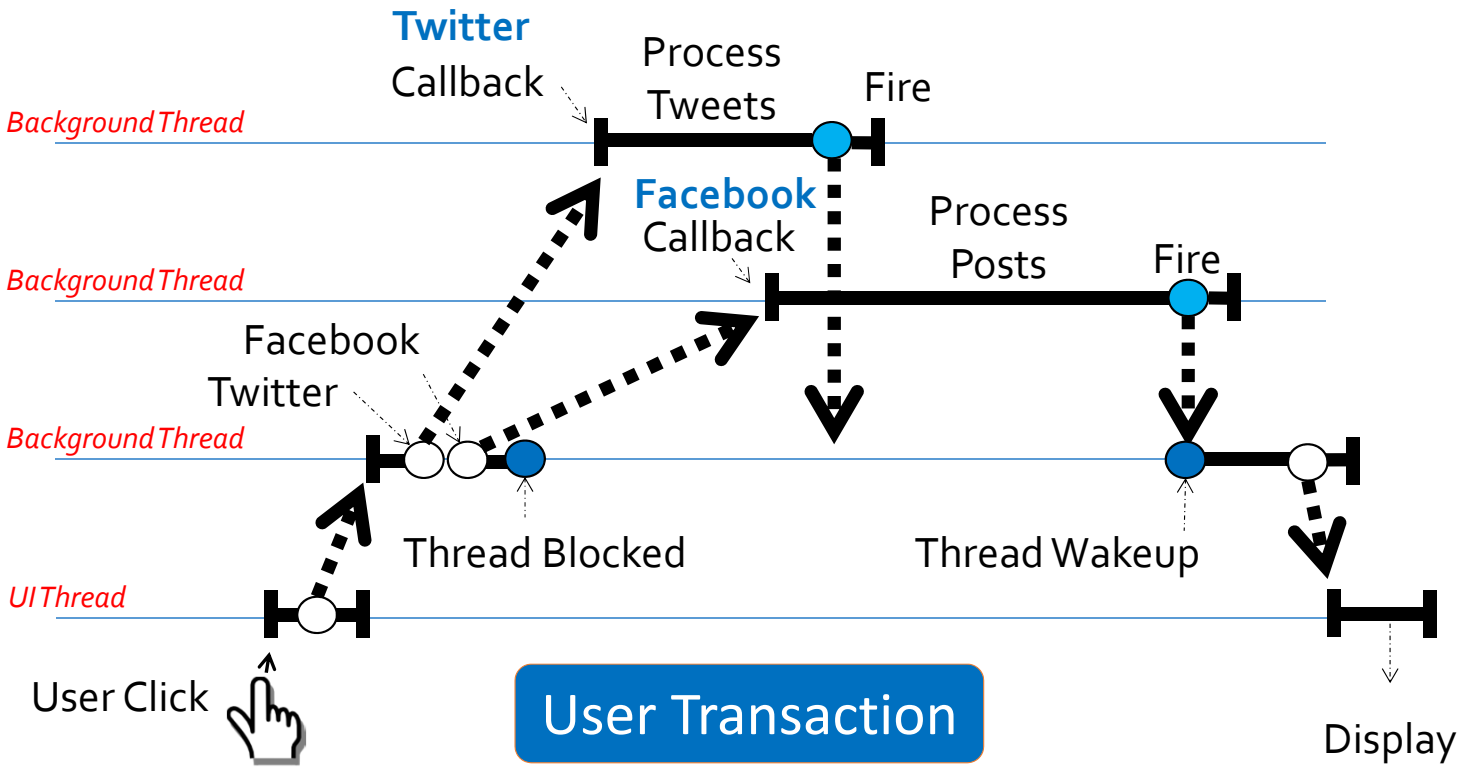
Background Thread
Thread Blocked
Thread Wakeup
UI Thread
User Click
User Transaction
Display


Twitter
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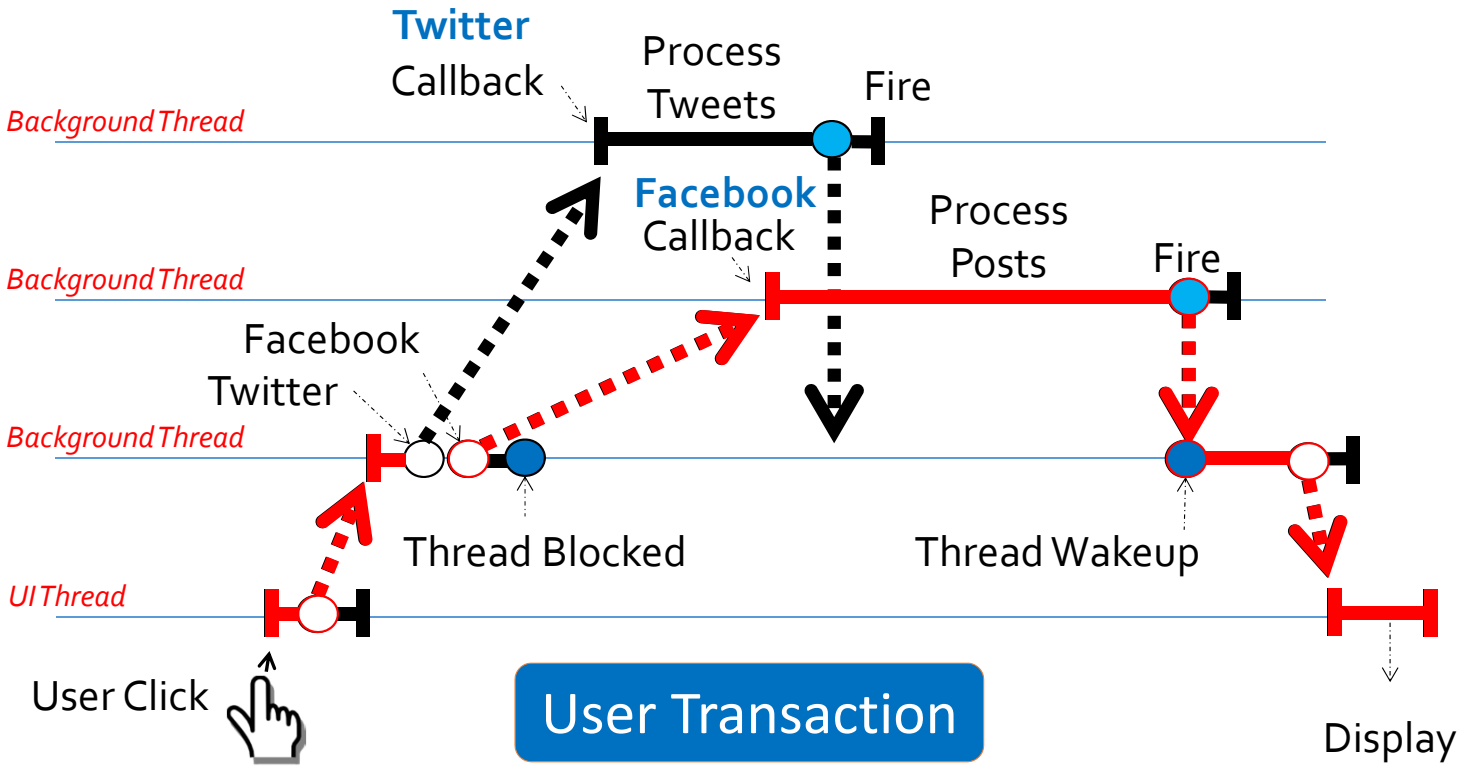
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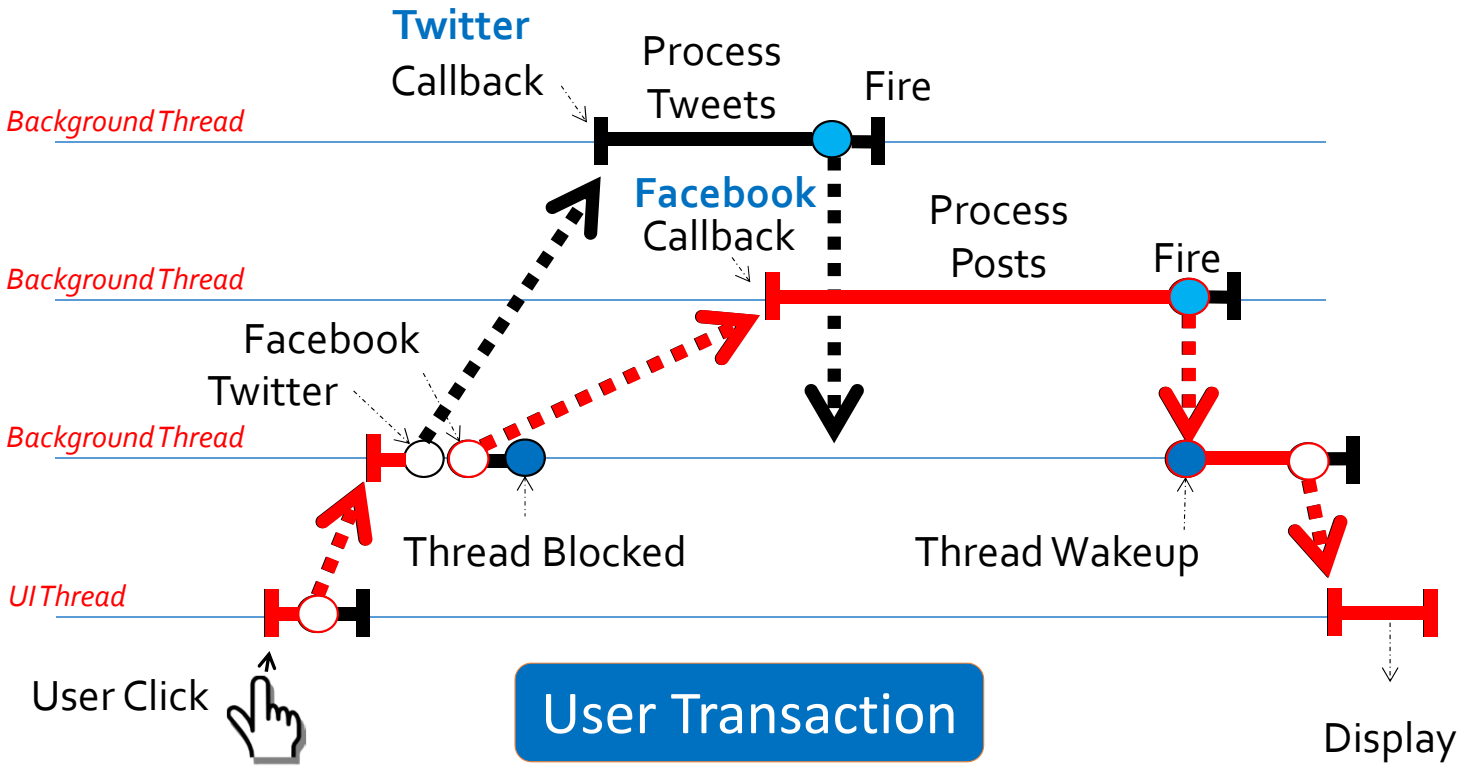
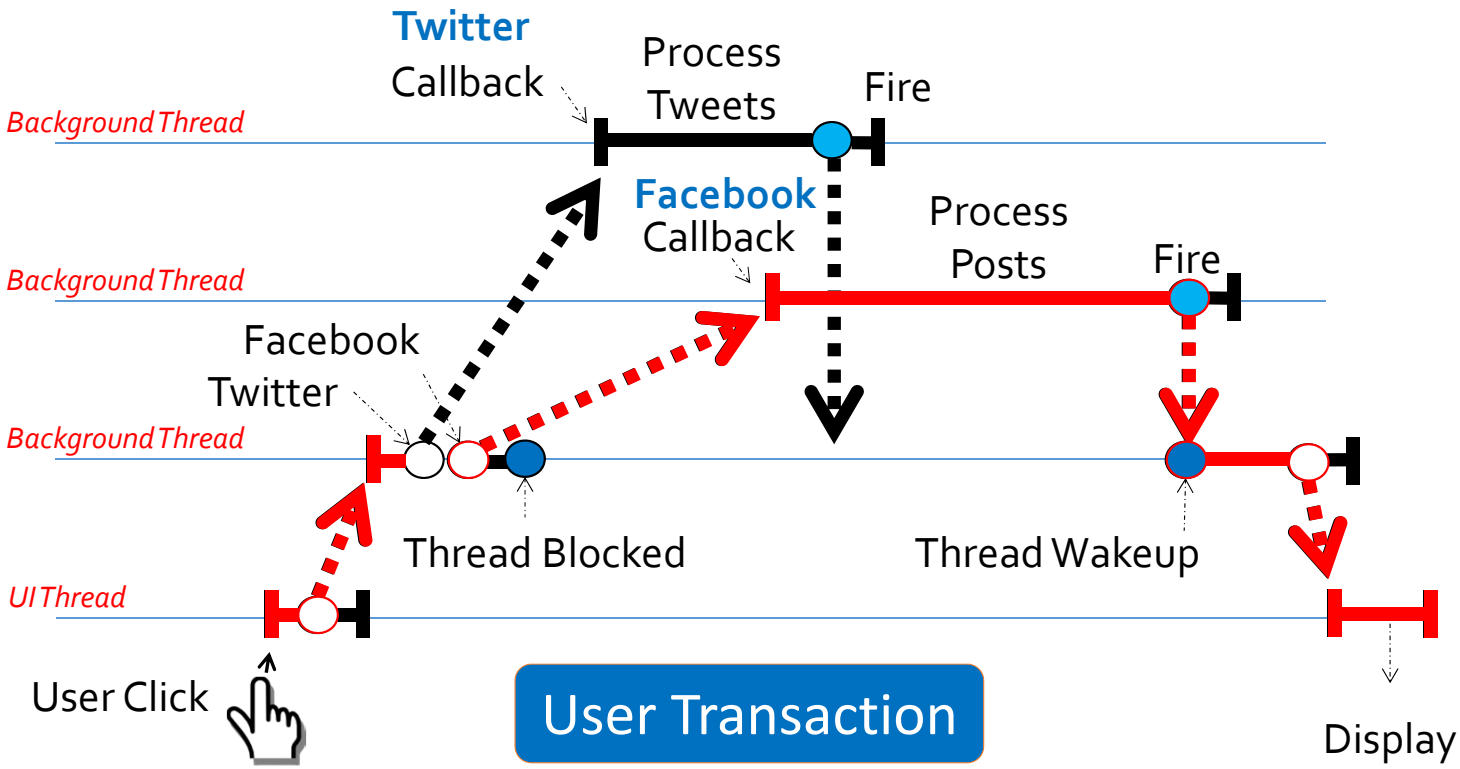
Critical Path



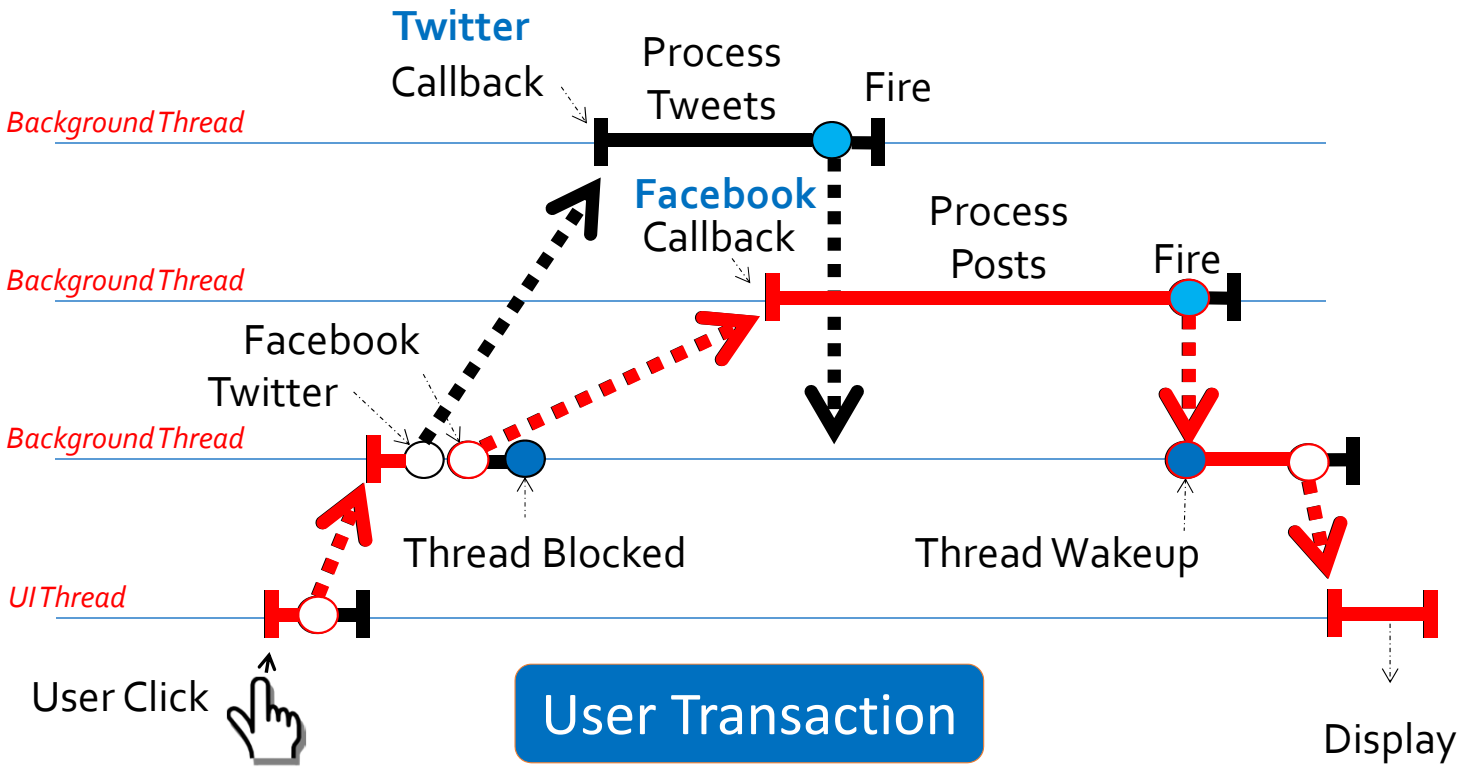
Critical Path

Optimizing the critical path reduces the user perceived delay



Critical Path

Optimizing the critical path reduces the user perceived delay

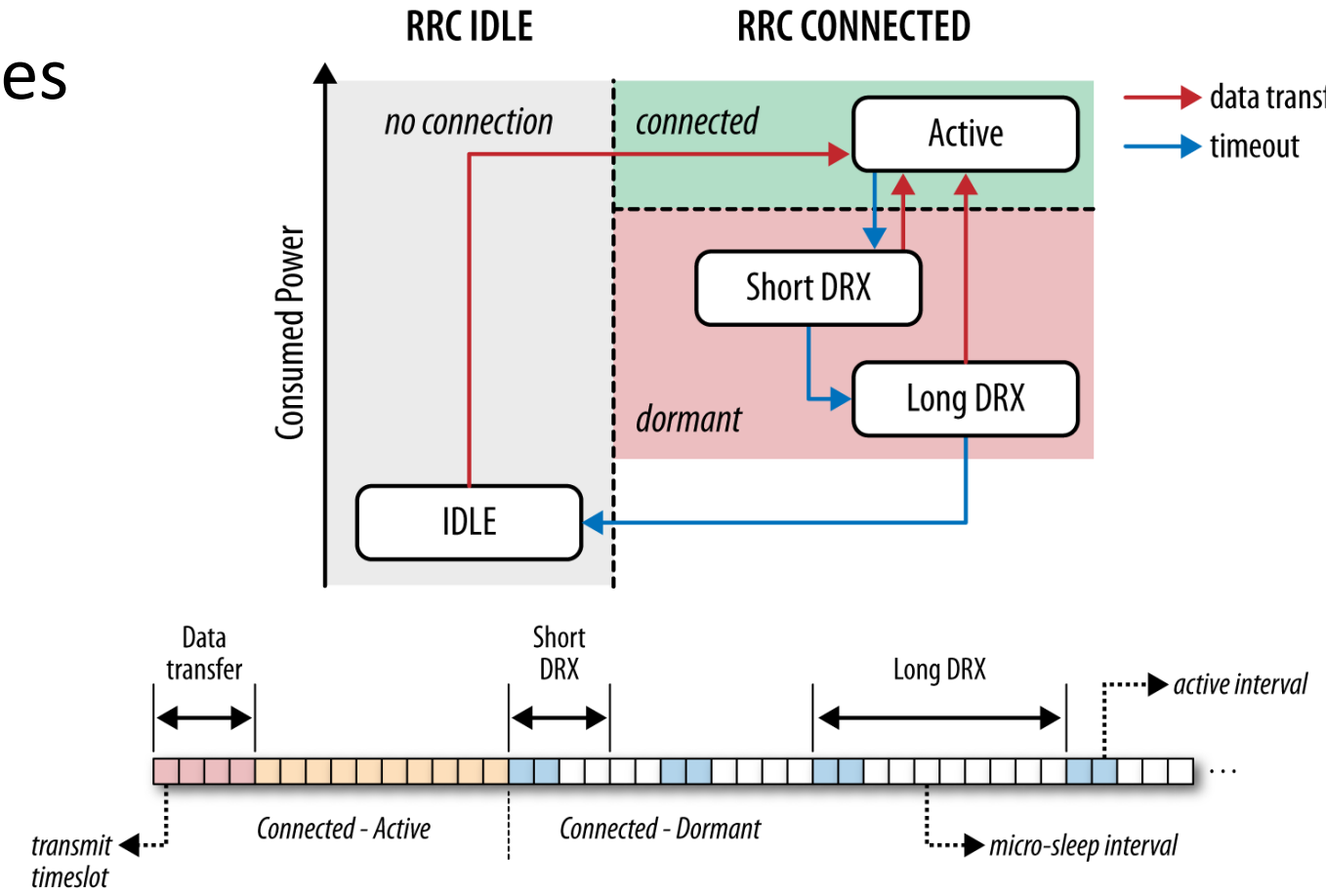


key points

- app pages designed in GUI
- async interfaces in code to UI elements
- async interfaces to network
- tendency to fetch many network objects at launch
- fetch-parse-fetch pattern
- critical path is hard to determine
- in which user transactions does network matter?
- of those, what caused network delay, if any?

cellular network complicates this even more

- radio power states



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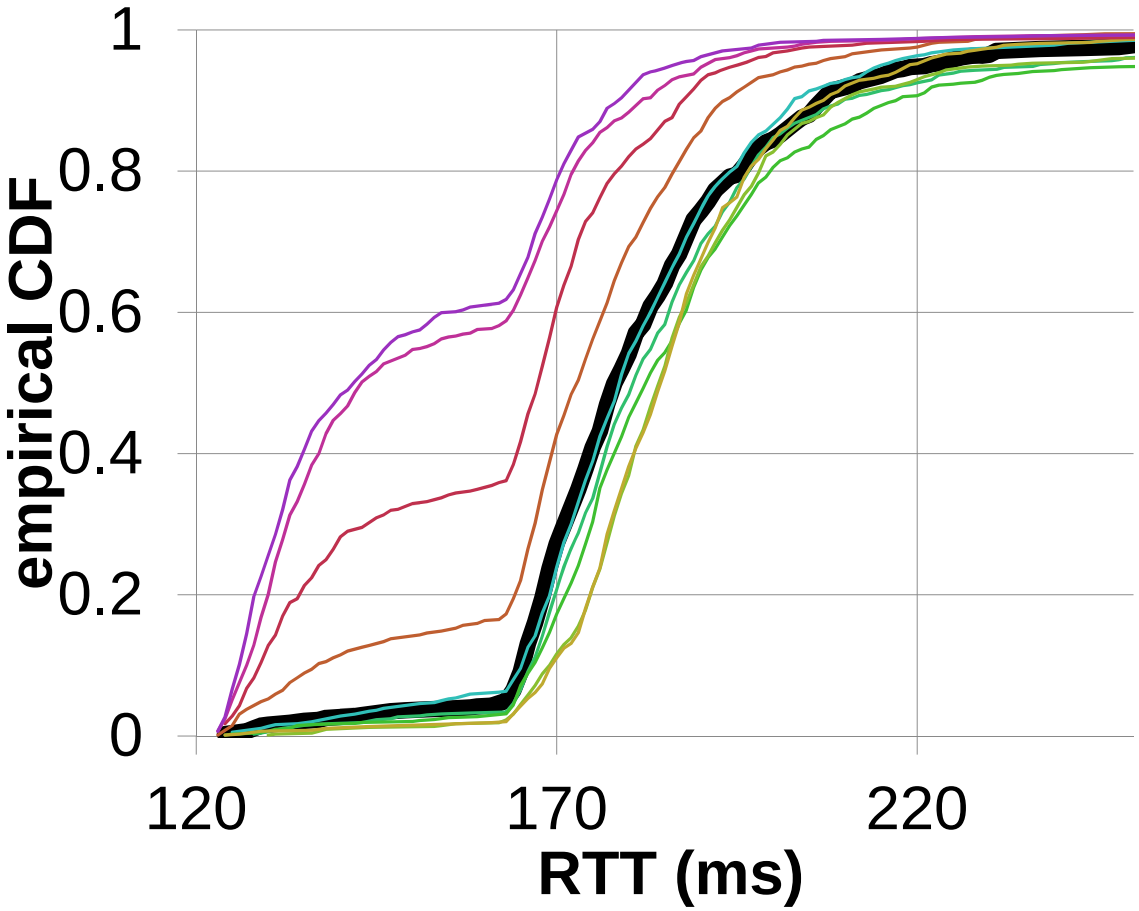
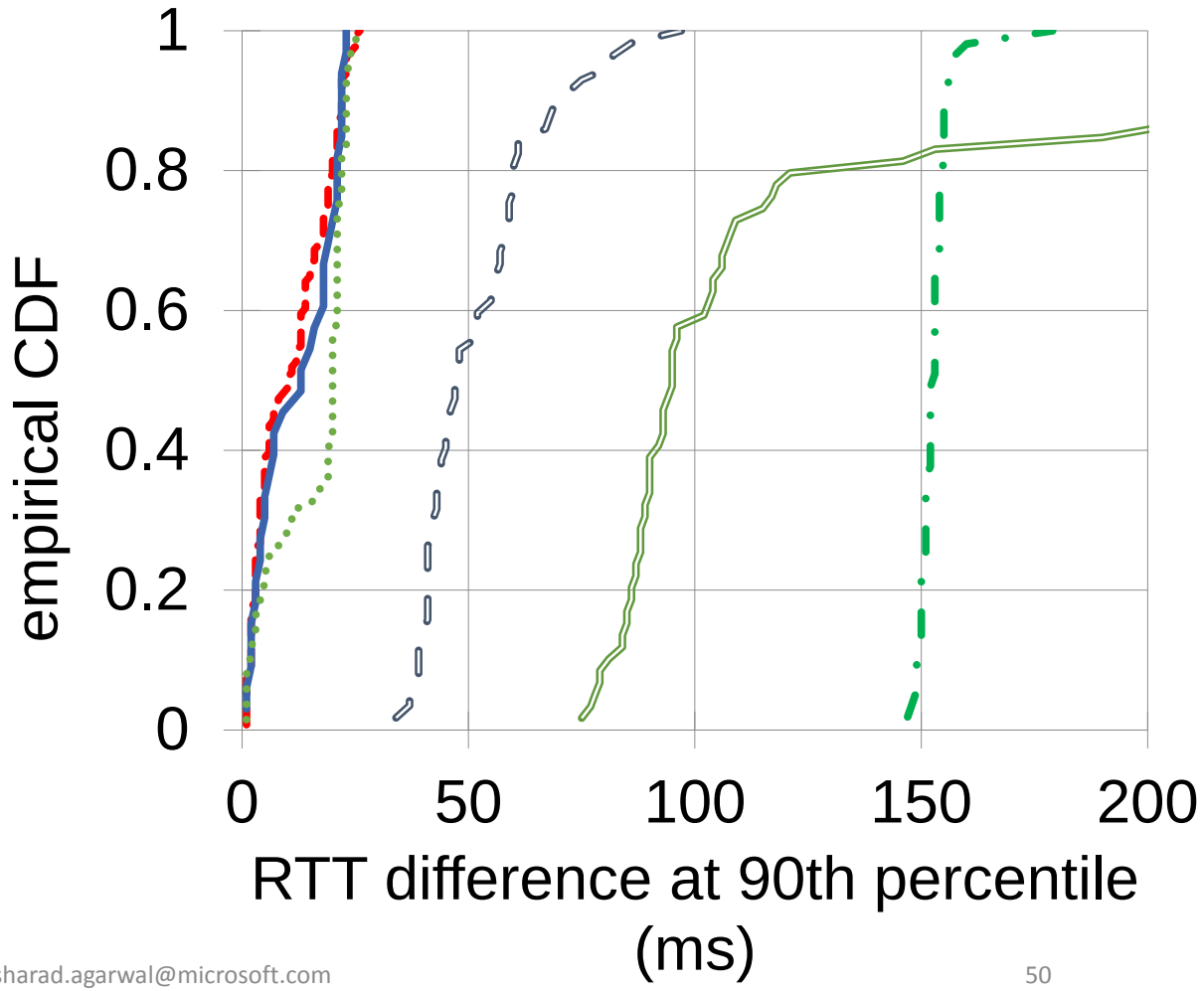


cellular network complicates this even more

- radio power states
- latency varies by load
- latency varies over space



why am I telling you all this?

- wireless BW, latency, RSSI, etc. data is useful for research
- relate it to user experience
  - this is hard because of how apps are built
  - need detailed & efficient app instrumentation
- our mobile OS throttles some network behavior
  - based on app performance need and cellular data limits
  - research systems to do this on a per app transfer basis, using detailed & lightweight instrumentation
- need detailed, predictive wireless performance info & how individual parts of apps are affected by net perf

for more details

- cellular performance variations in short timescales
  - Switchboard paper in ACM MobiSys 2011
- asynchronous nature of apps & perf measurement
  - AppInsight paper in USENIX OSDI 2012
- network fetching behavior of apps
  - Procrastinator paper in ACM MobiSys 2014