




# A Provider-side View of Web Search Response Time

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MICROSOFT



Web services are the dominant way  
to find and access information

# Web service latency is critical to service providers as well

► Google



Latency  
+0.5 sec



revenue  
-20%

► Bing

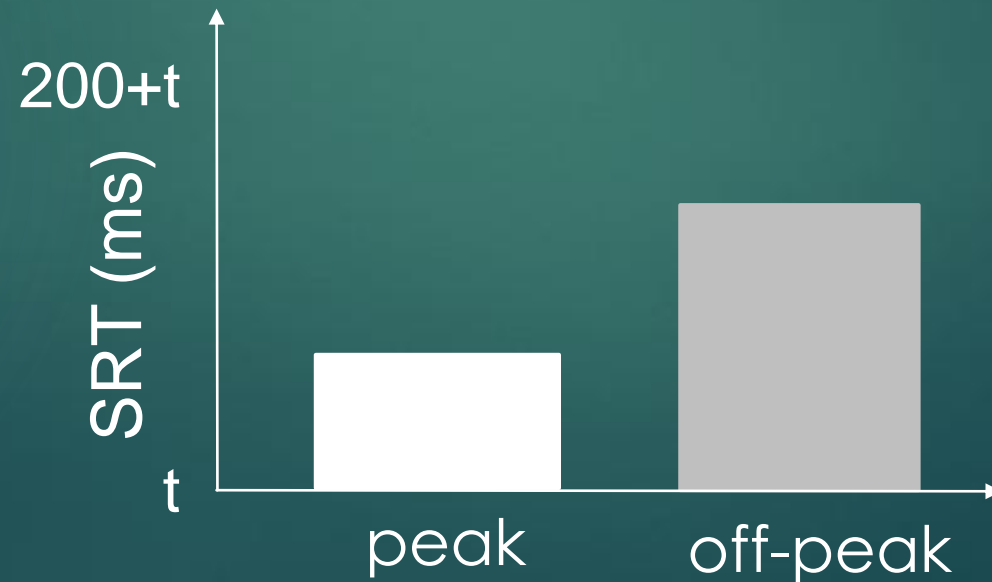
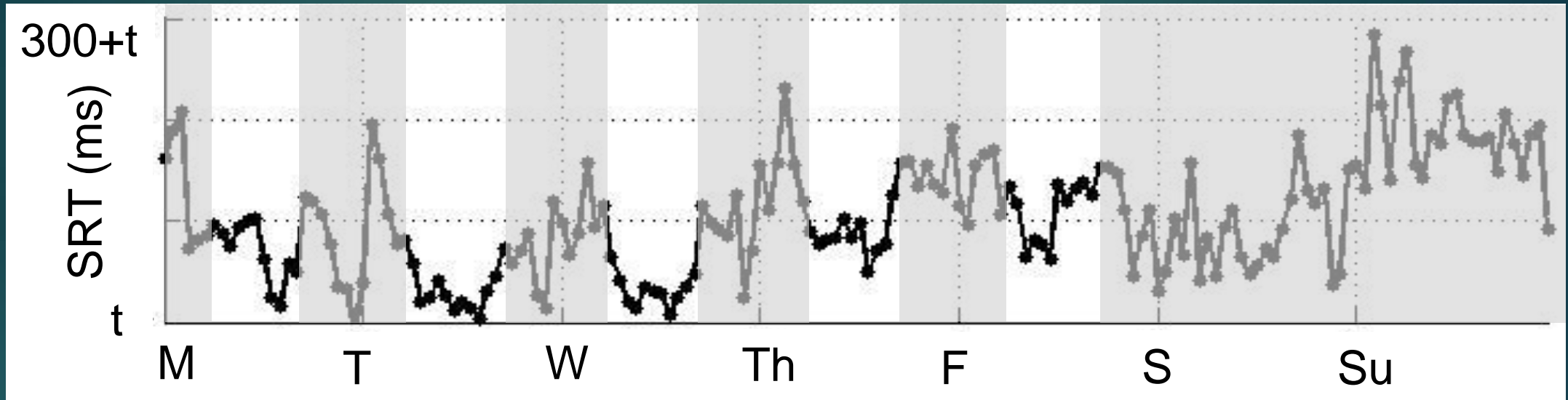


Latency  
+2 sec



revenue  
-4.3%

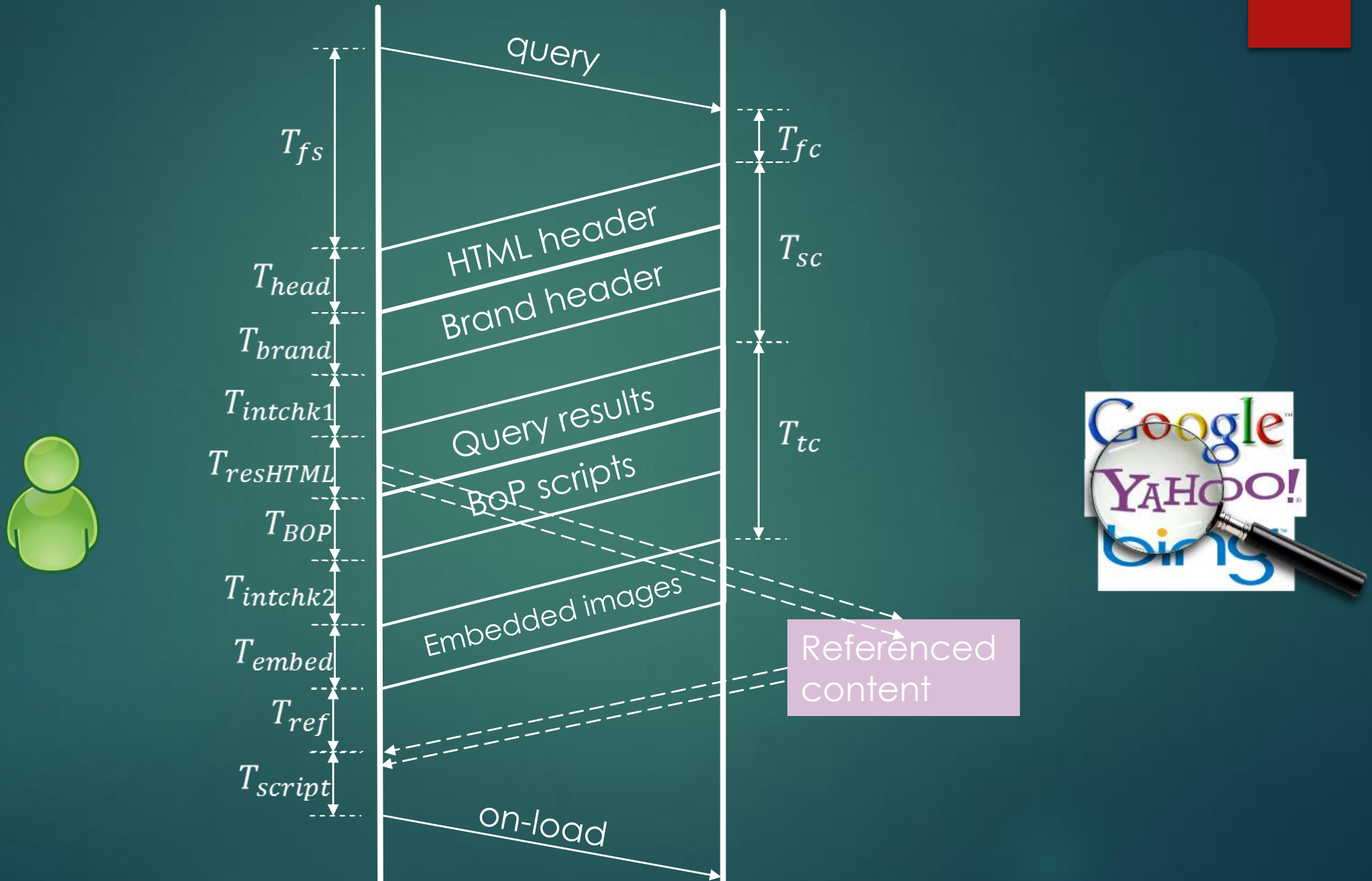
# Understanding SRT behavior is challenging



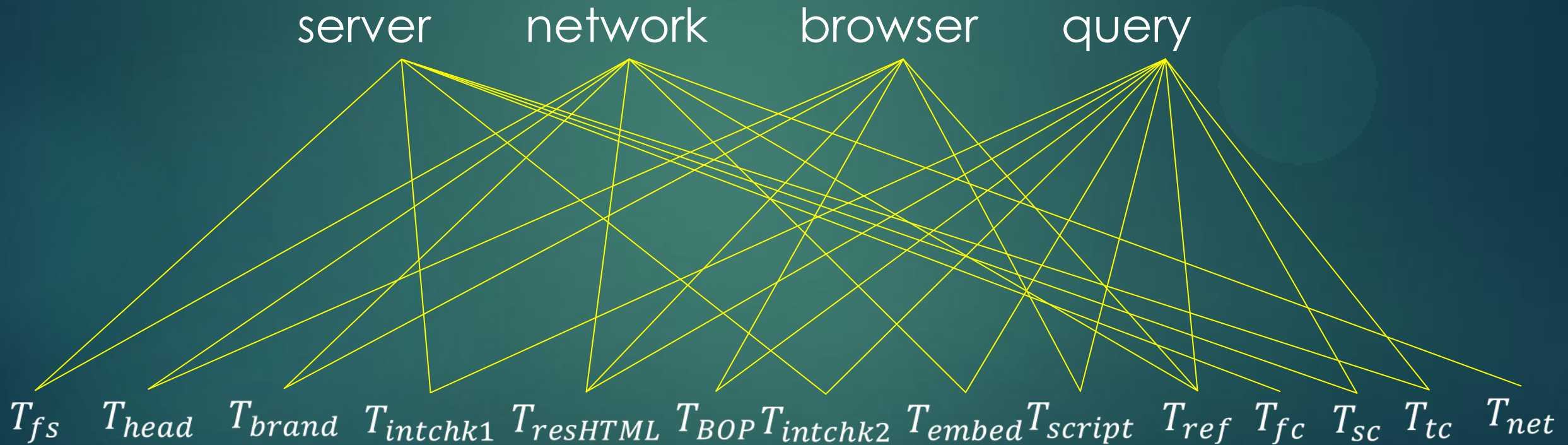
# Our work

- ▶ Explaining systemic SRT variation
- ▶ Identify SRT anomalies
- ▶ Root cause localization

# Client- and server-side instrumentation



# Impact Factors of SRT



# Primary factors of SRT variation

- Apply Analysis of Variance (ANOVA) on the time intervals

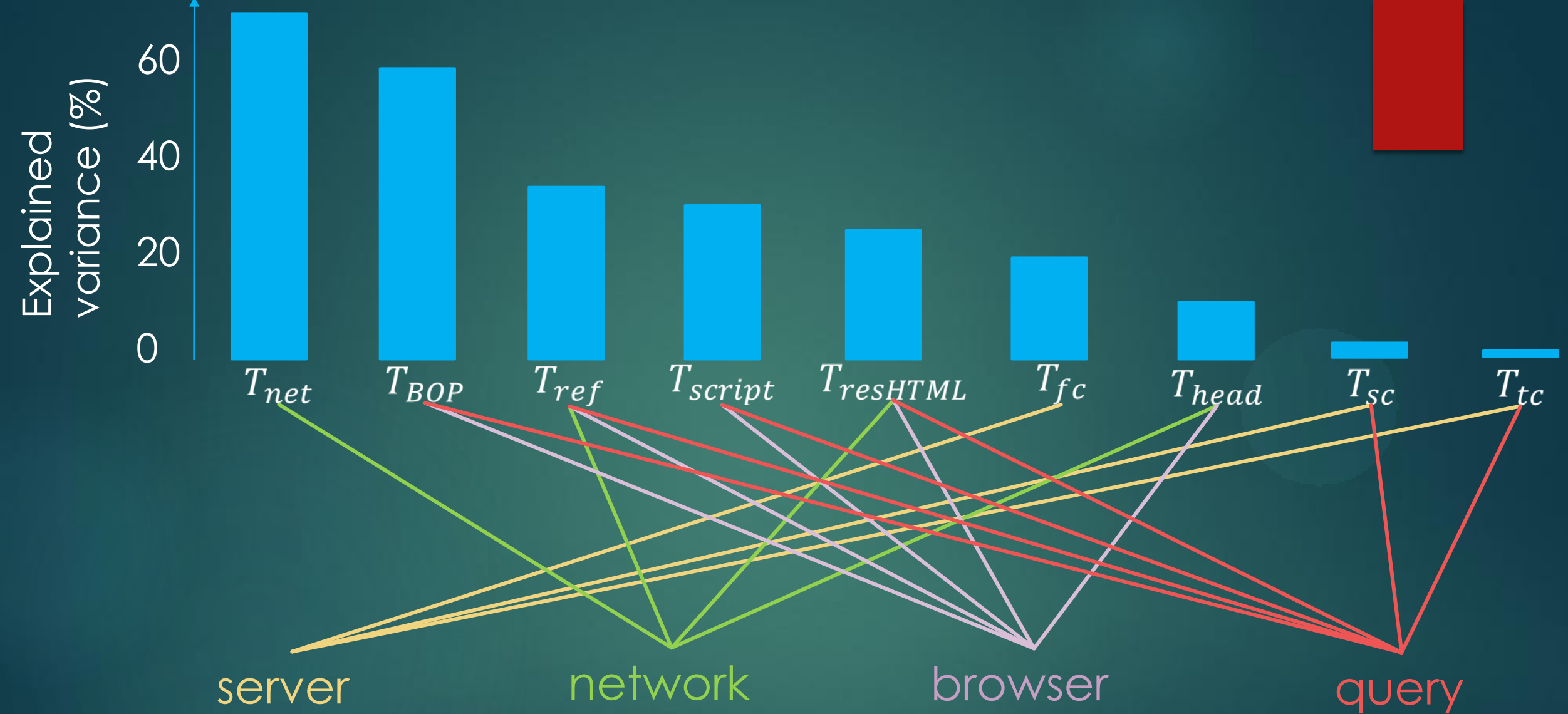
$$Var(SRT) = \sum_k Var(T_k, SRT) + \eta$$

SRT  
variance

Variance explained  
by time interval k

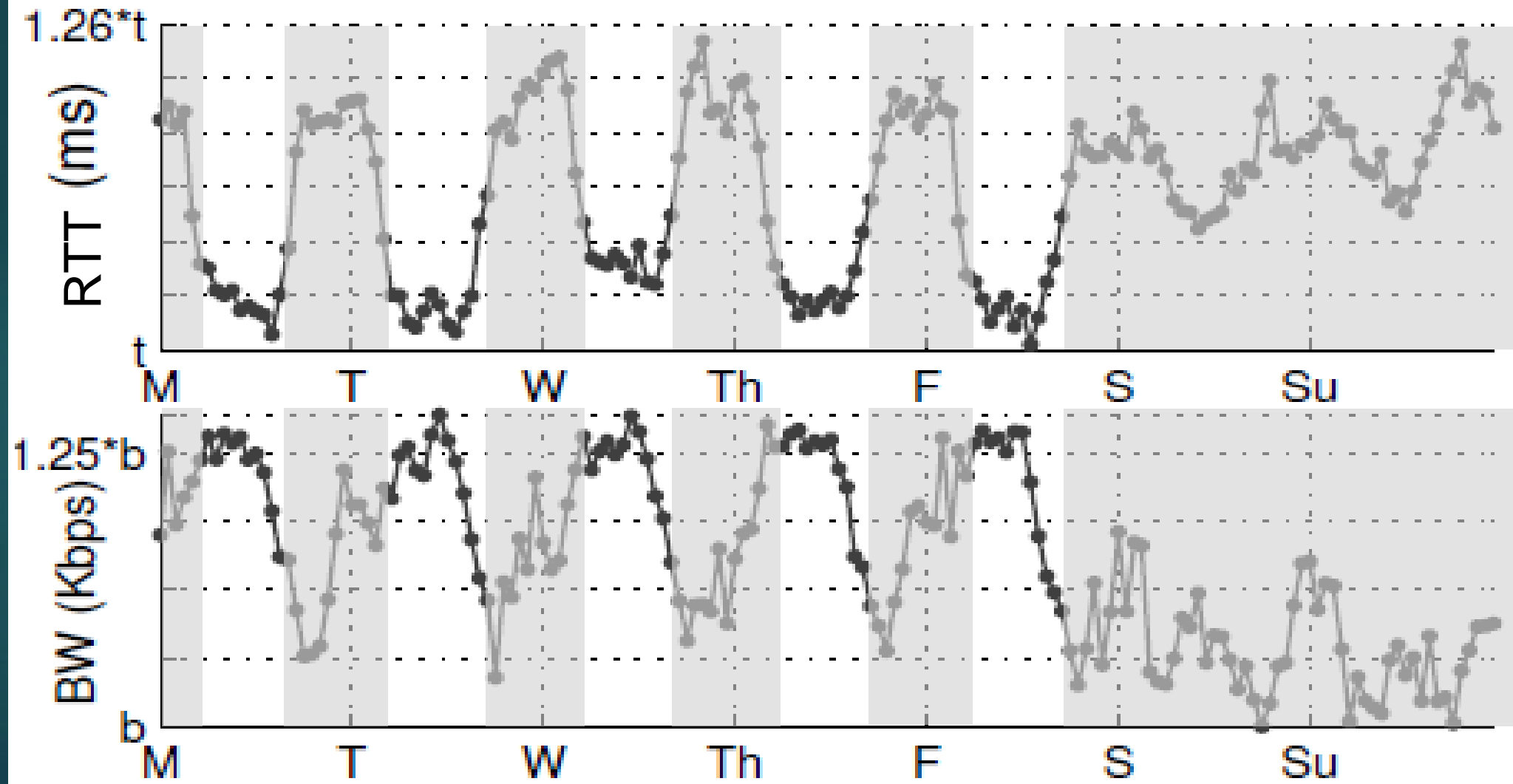
Unexplained  
variance





- ▶ Primary factors: network characteristics, browser speed, query type
- ▶ Server-side processing time has a relatively small impact

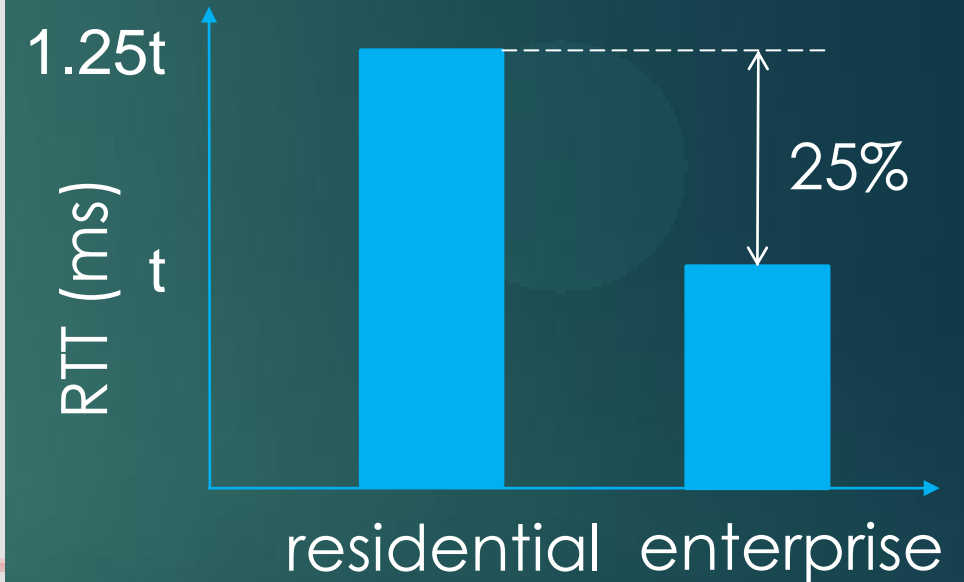
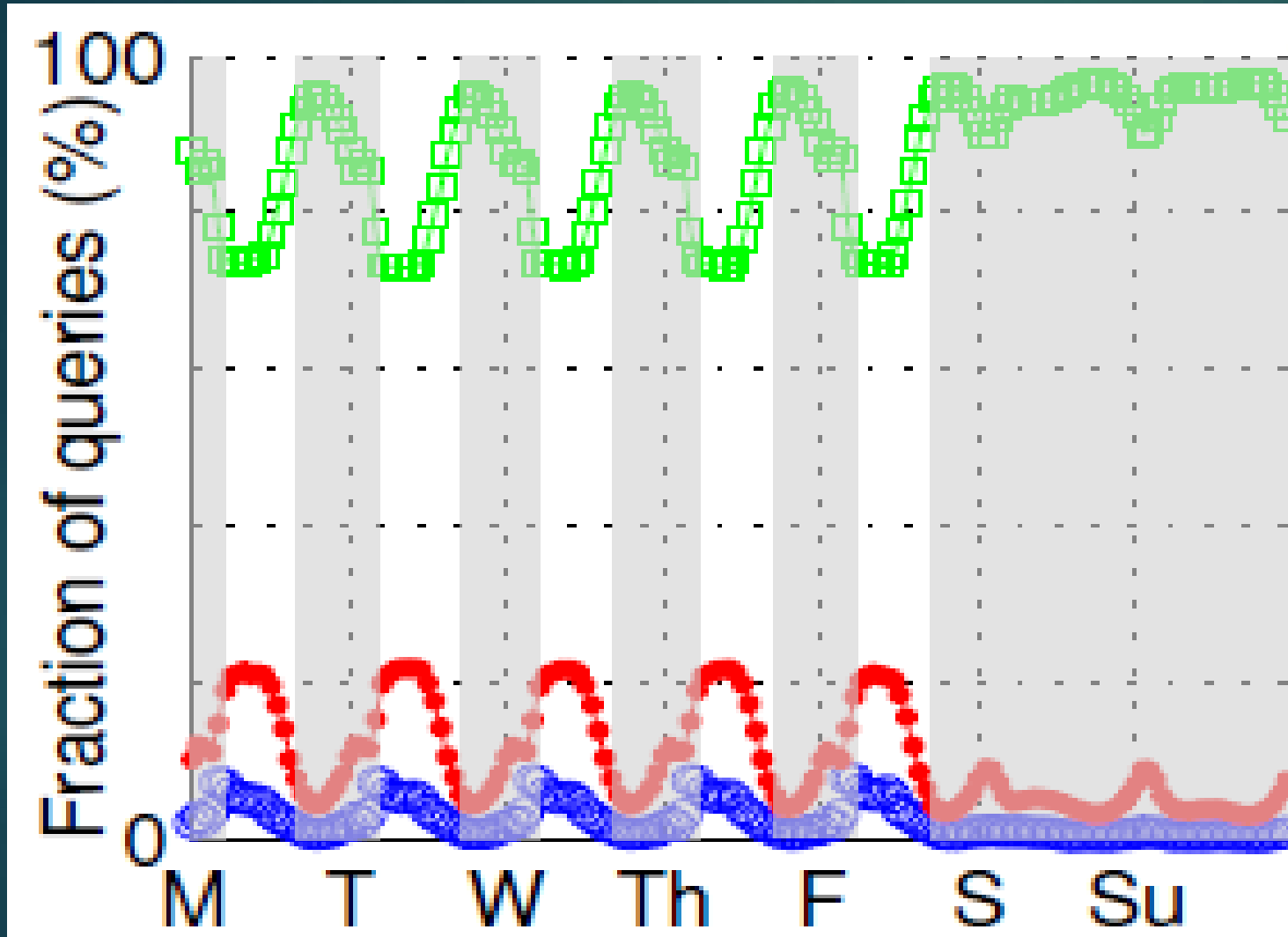
# Variation in network characteristics



# Explaining network variations

- ▶ Residential networks send a higher fraction of queries during off-peak hours than peak hours
- ▶ Residential networks are slower

■ residential ■ enterprise ■ unknown

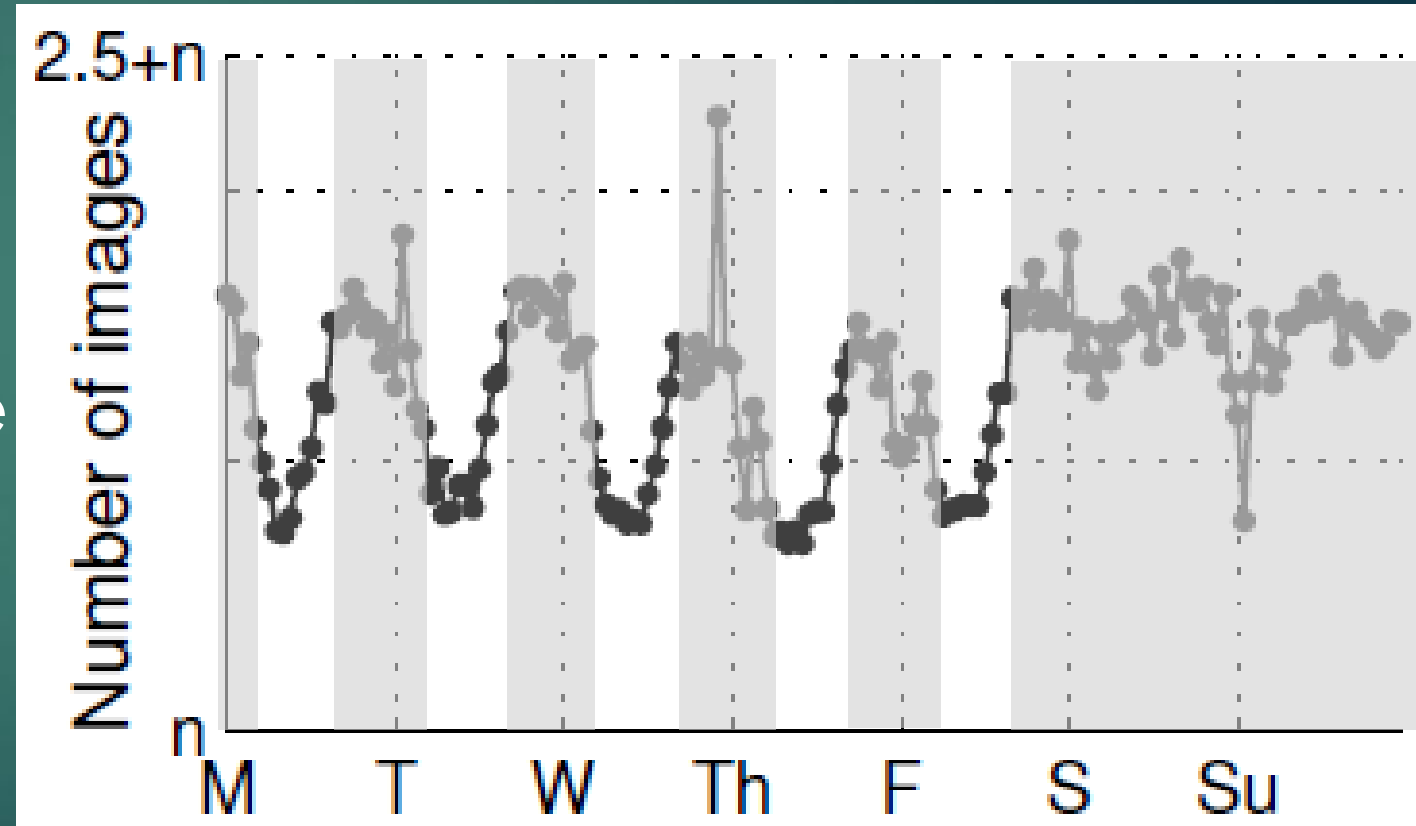


Residential networks are slower

Residential networks send a higher fraction of queries during off-peak hours than peak hours

# Variation in query type

- ▶ Impact of query on SRT
  - ▶ Server processing time
  - ▶ Richness of response page
- ▶ Measure: number of image



# Explaining query type variation

## Peak hours

WEB IMAGES VIDEOS MAPS

correlation coefficient

1,270,000 RESULTS Any time ▾

[Correlation coefficient - Wik](#)

[en.wikipedia.org/wiki/Correlation\\_coefficient](http://en.wikipedia.org/wiki/Correlation_coefficient) ▾

**Correlation coefficient** may refer to: Pearson product-moment **correlation coefficient** also known as  $r$ ,  $R$ , or Pearson's  $r$ , a measure of the strength and direction of ...

[correlation coefficient: Definition from Answers.com](#)

[www.answers.com](http://www.answers.com) ▾ Library ▾ Literature & Language ▾ Dictionary ▾

**correlation coefficient** *n.* A measure of the interdependence of two random variables that ranges in value from -1 to +1, indicating perfect negative **correlation**

[Statistics 2 - Correlation Coefficient and Coefficient of ...](#)

[mathbits.com/MathBits/TISection/Statistics2/correlation.htm](http://mathbits.com/MathBits/TISection/Statistics2/correlation.htm) ▾

The quantity  $r$ , called the linear **correlation coefficient**, measures the strength and direction of a linear relationship between two variables.

[Correlation and dependence - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/Correlation](http://en.wikipedia.org/wiki/Correlation) ▾

Pearson's product ... - Rank **correlation** ... - Other measures of ...



## Off-peak hours

WEB IMAGES VIDEOS MAPS NEWS

lady gaga

39,100,000 RESULTS Any time ▾

[News about Lady Gaga](#)

[bing.com/news](http://bing.com/news)



[Lady Gaga, Madonna Facing Punishment in Russia](#)  
ABC News · 3 days ago

Pop stars **Lady Gaga** and Madonna are facing punishment in Russia after authorities determined they violated their...

[Secrets about Lady Gaga's financial and personal life to be kept under seal: Judge](#)  
New York Daily News · 2 days ago

[Lady Gaga participates in Marina Abramovic's 'Solaris' reading](#)  
Los Angeles Times · 2 days ago

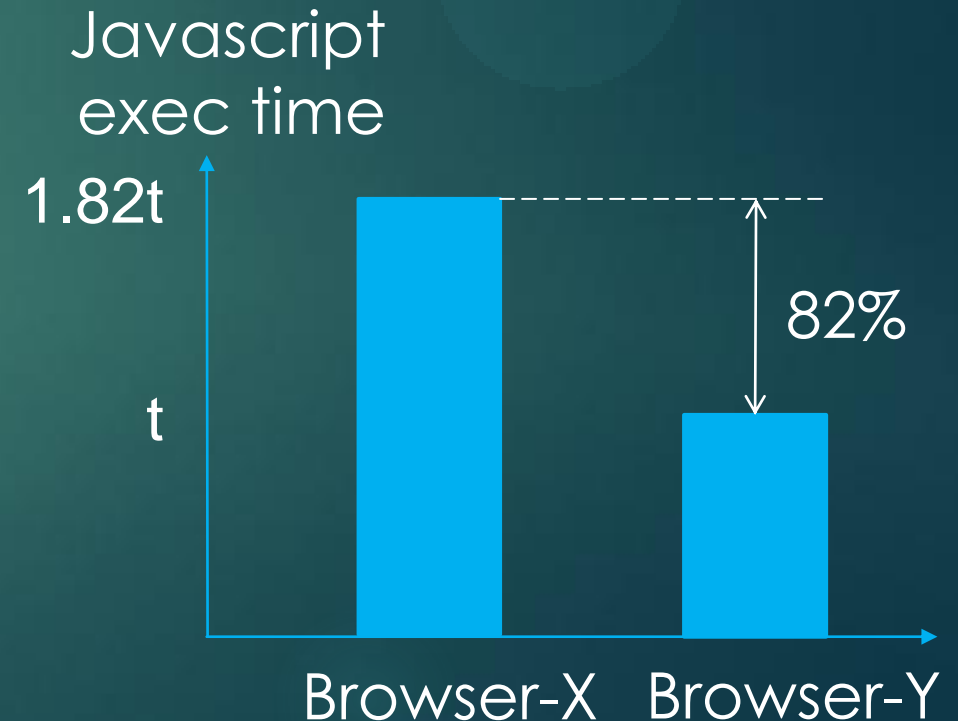
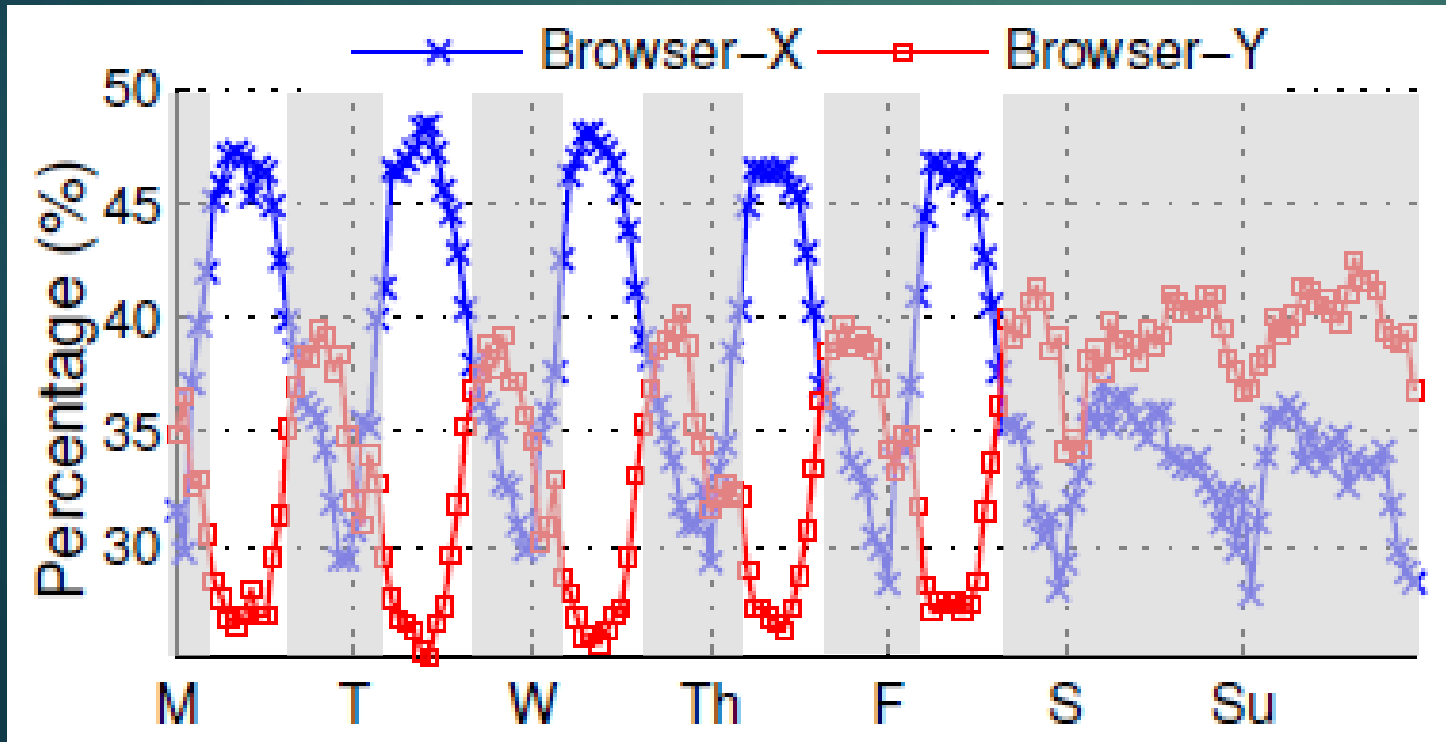
[Lady Gaga - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/Lady\\_Gaga](http://en.wikipedia.org/wiki/Lady_Gaga) ▾



# Browser variations

- ▶ Two most popular browsers: X(35%), Y(40%)
- ▶ Browser-Y sends a higher fraction of queries during off-peak hours
- ▶ Browser-Y has better performance



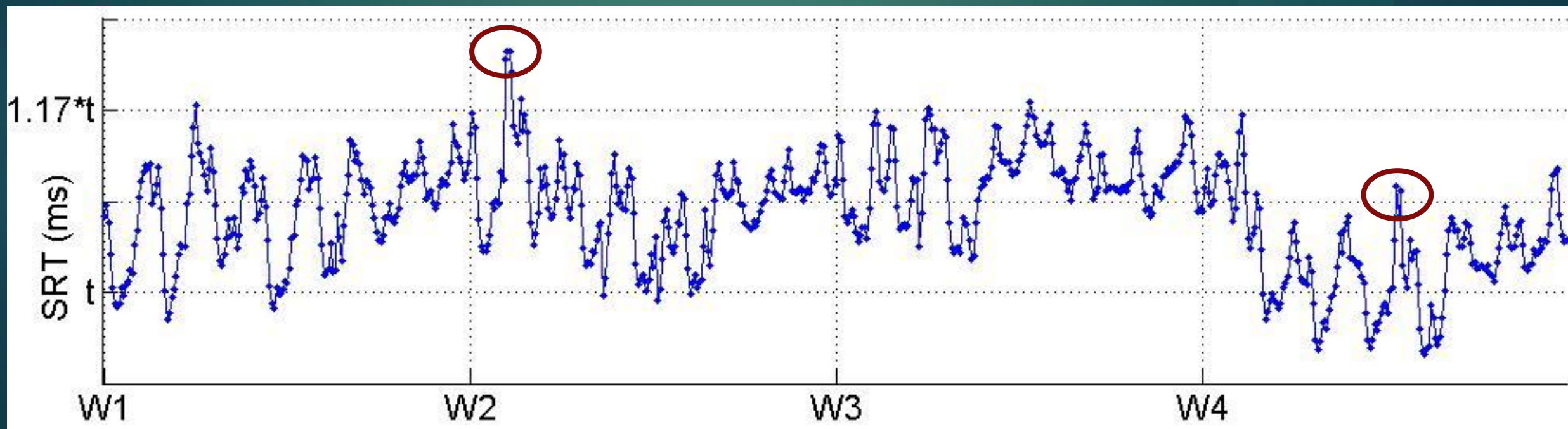
# Summarizing systemic SRT variation

- ▶ Server: Little impact
- ▶ Network: Poorer during off-peak hours
- ▶ Query: Richer during off-peak hours
- ▶ Browser: Faster during off-peak hours



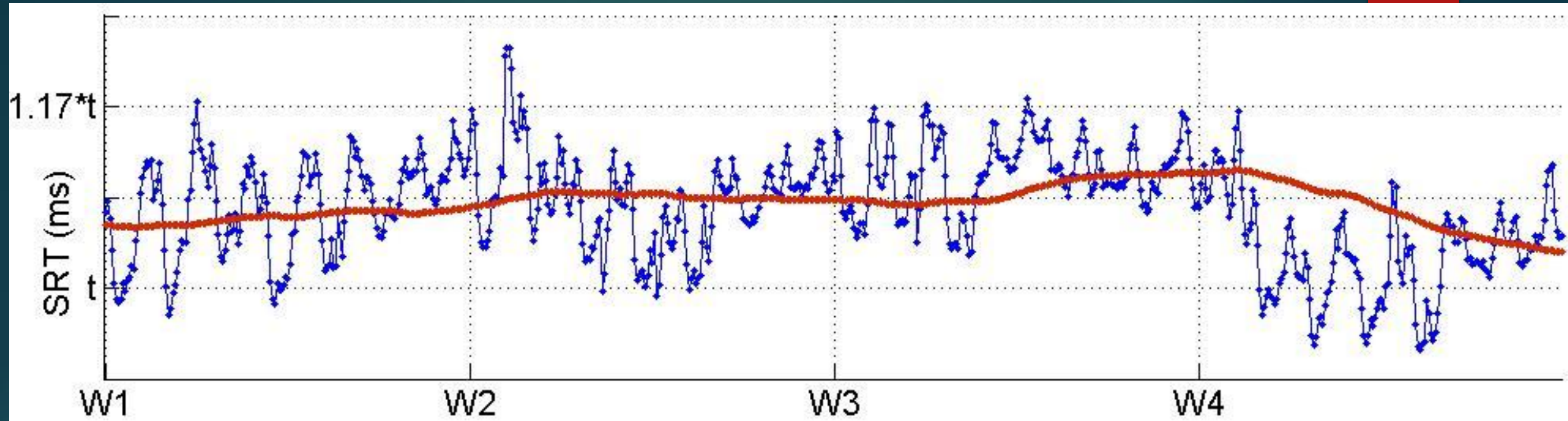
# Detecting anomalous SRT variations

- Challenge: interference from systemic variations

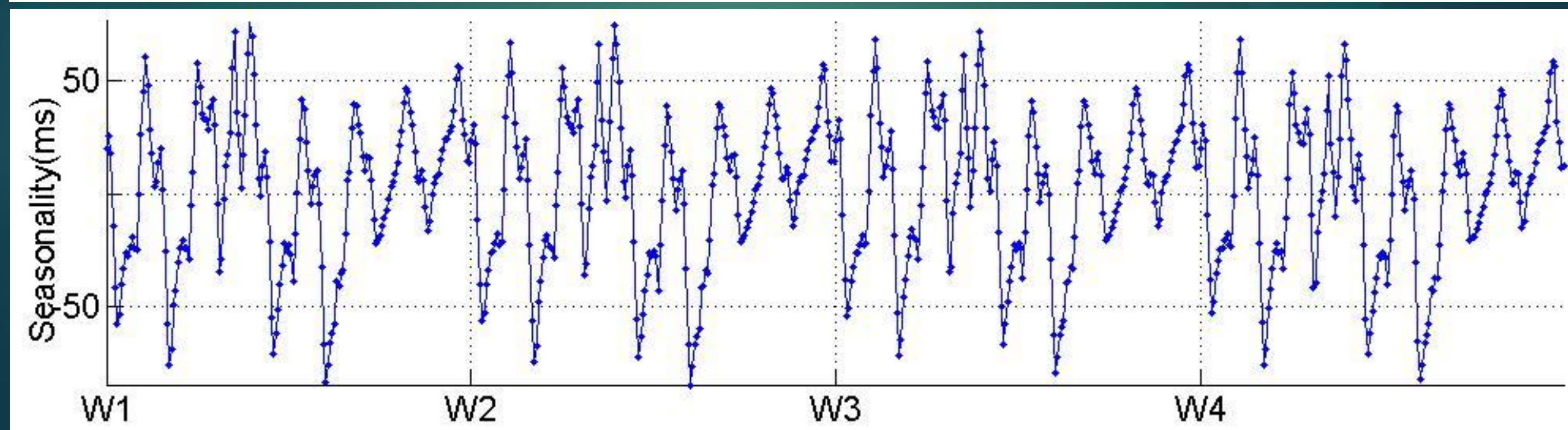
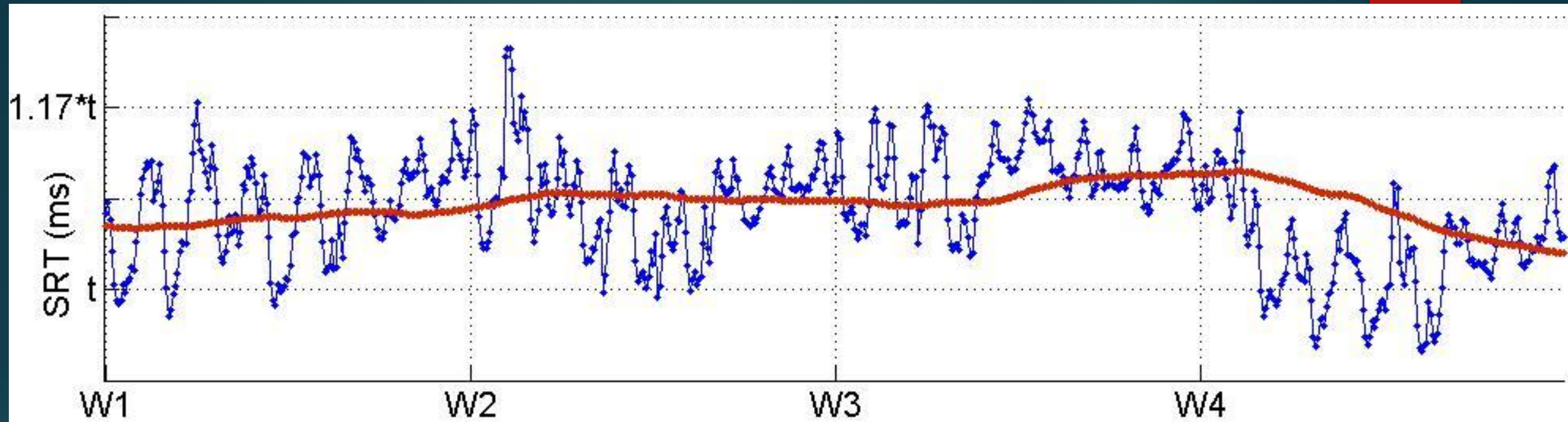


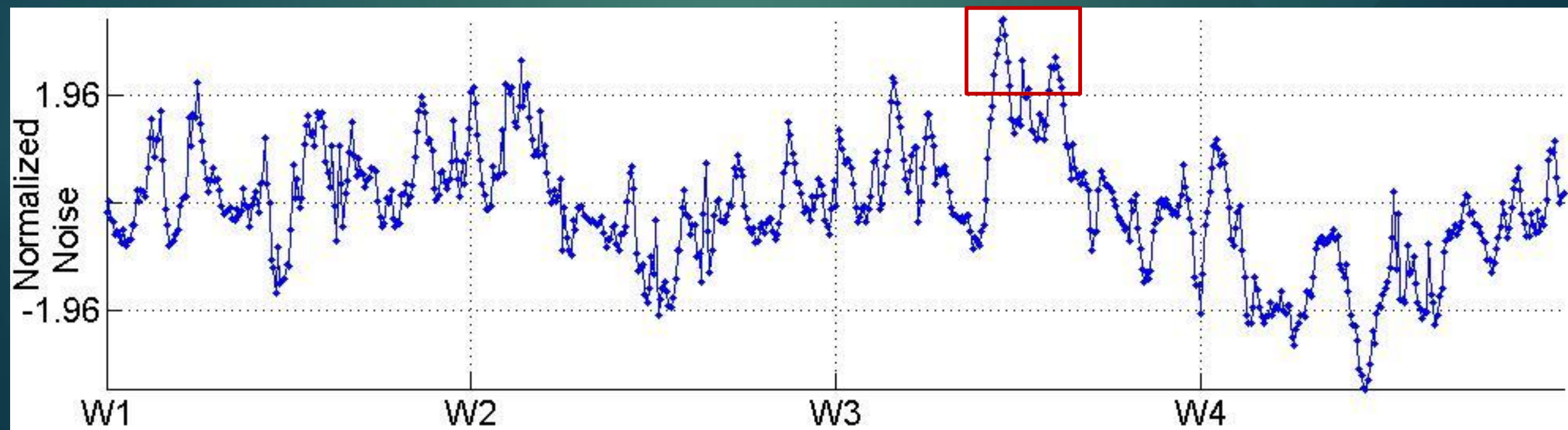
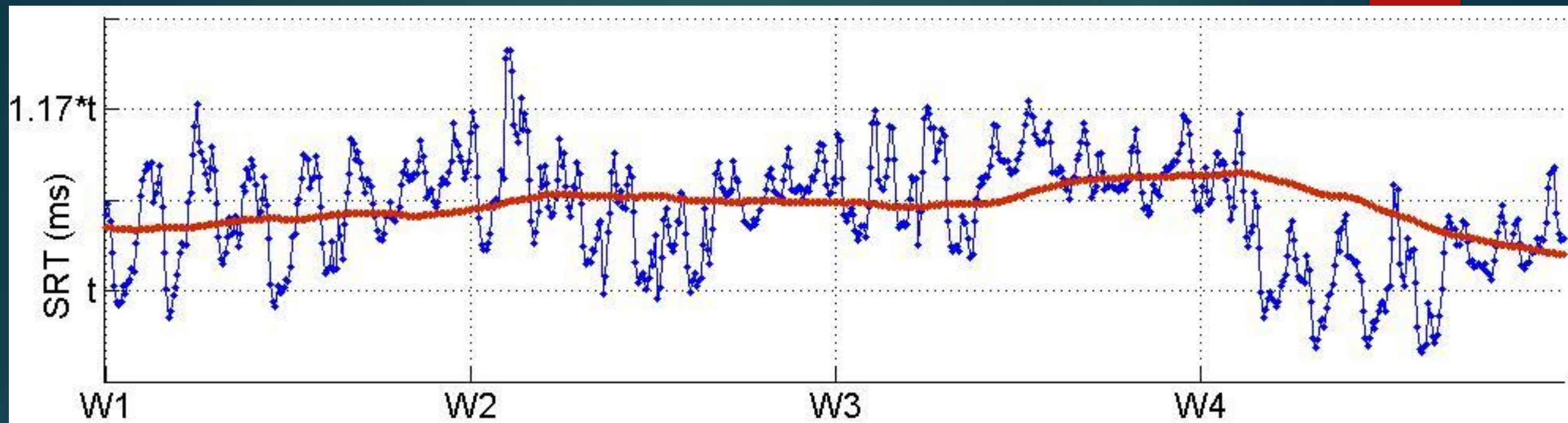
# Week-over-Week (WoW) approach

$$SRT = \text{Long term trend} + \text{Seasonality} + \text{Noise}$$











# Comparison with approaches that do not account for systemic variations

	WoW	One Gaussian model of SRT	Change point detection
False negative	10%	35%	40%
False positive	7%	17%	19%

# Conclusions

- ▶ Understanding SRT is challenging
  - ▶ Changes in user demographics lead to systemic variations in SRT
- ▶ Debugging SRT is challenging
  - ▶ Must factor out systemic variations

# Implications

- ▶ Performance monitoring
  - ▶ Should understand performance-equivalent classes
- ▶ Performance management
  - ▶ Should consider the impact of network, browser, and query
- ▶ Performance debugging
  - ▶ End-to-end measures are tainted by user behavior changes



Questions?

