

Introduction and Motivation

- **Goal**
 - integration of meaningful feedback about the requirements and performance of multimedia applications into adaptive multimedia networking.
- **We would like to explore**
 - mechanisms for long-term characterization of network variability (e.g., delay, bandwidth, buffer size).
 - mechanisms for inducing application requirements into adaptive multimedia networking.
- **We would these mechanisms**
 - to be robust and easy to implement.

Outline of the Talk

- **Statistical Process Control & Multimedia Networking**

- Long-Term vs. Short-Term Variability
- Statistical Quality Control
- Long-Term Stability Monitor



- **Applications of SPC to Adaptive Rate Control**

- Adaptive Media Coding
- Adaptive Media Synchronization

- **Conclusions**

Outline of the Talk

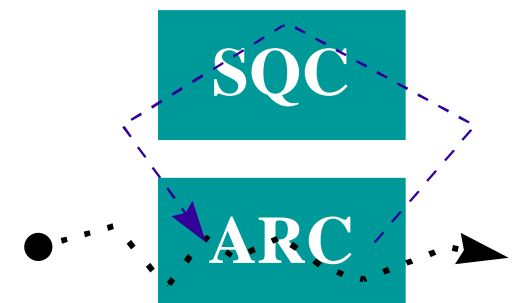
- **Statistical Process Control & Multimedia Networking**

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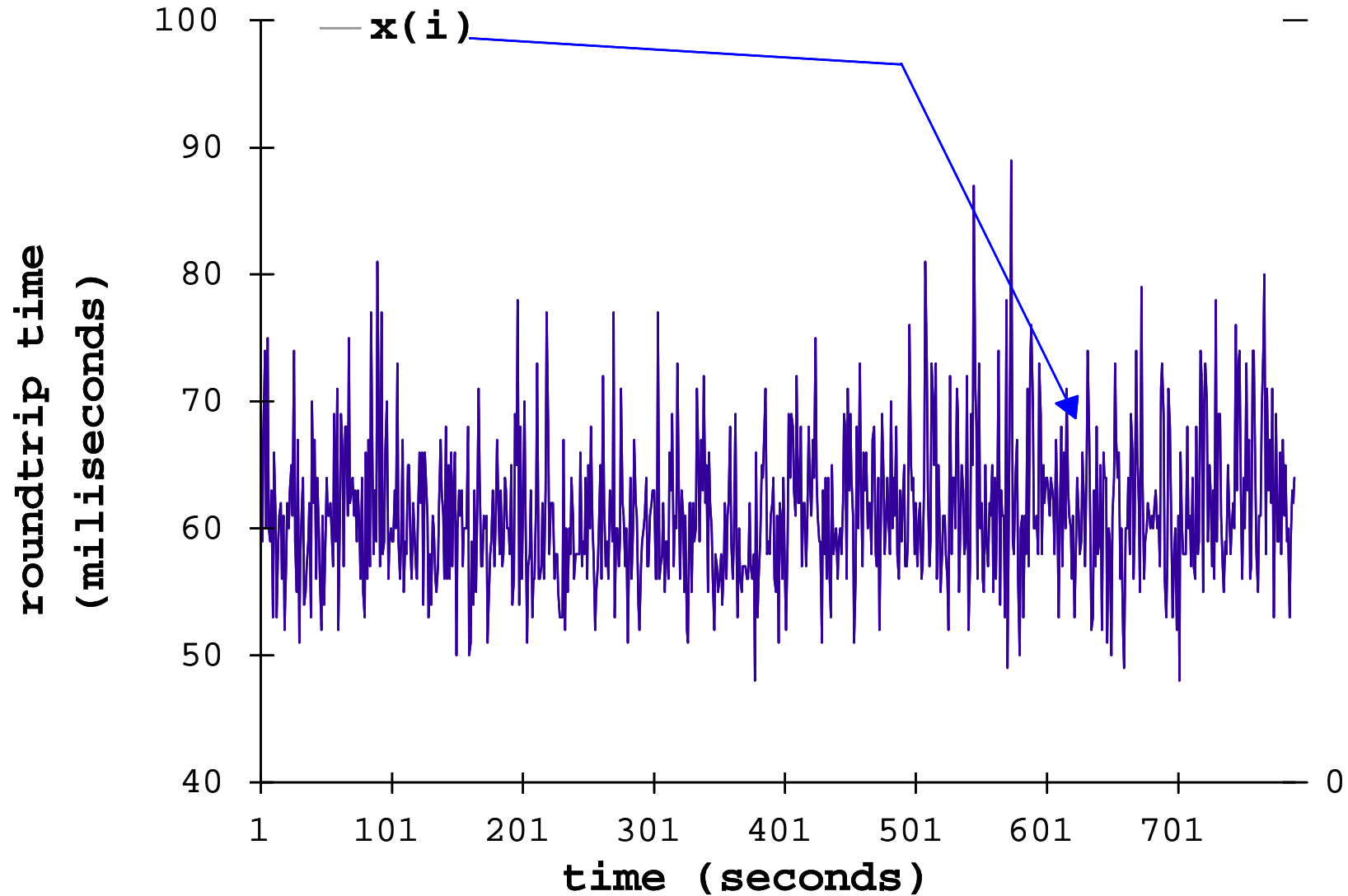
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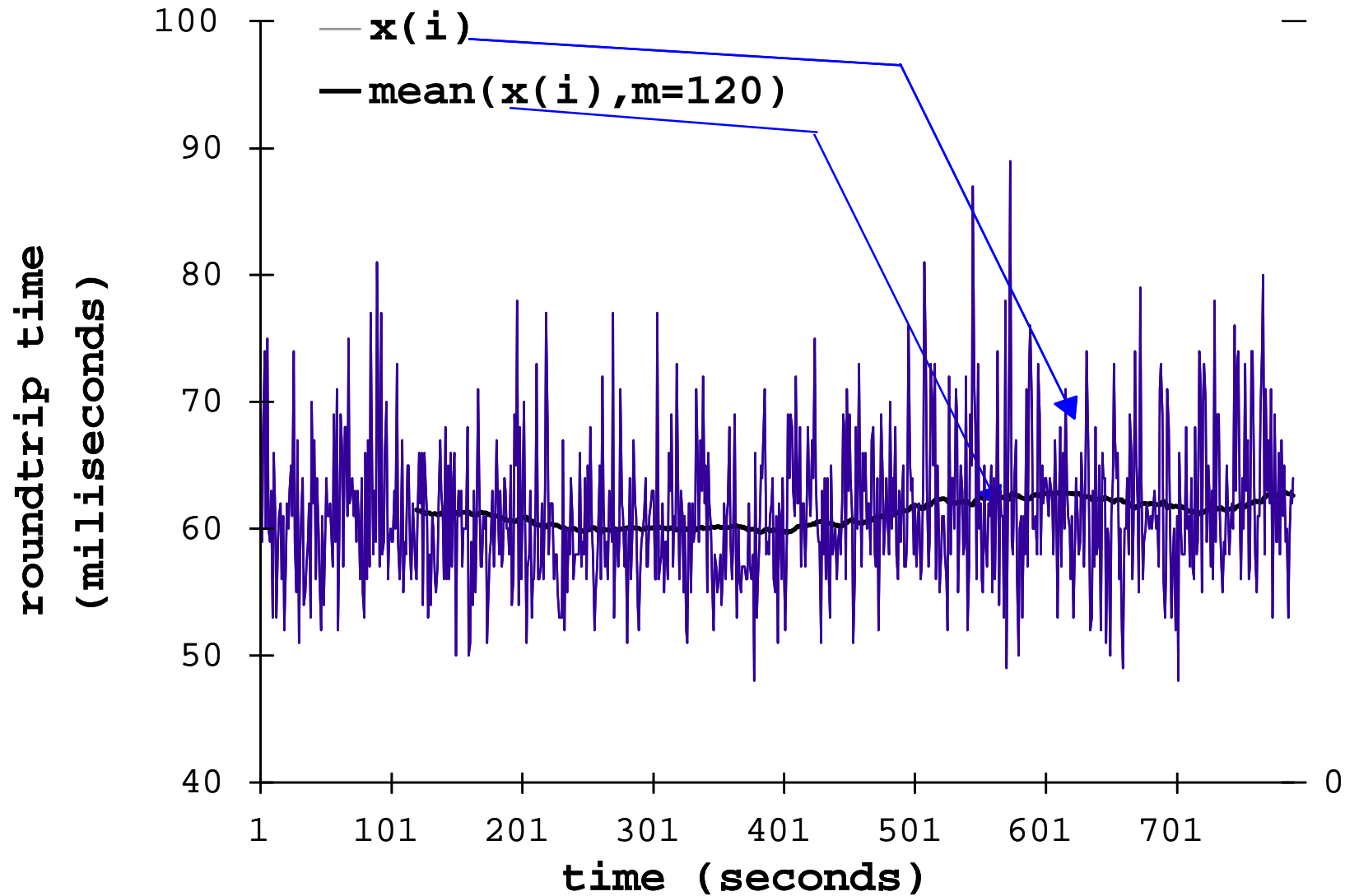


- **Conclusions**

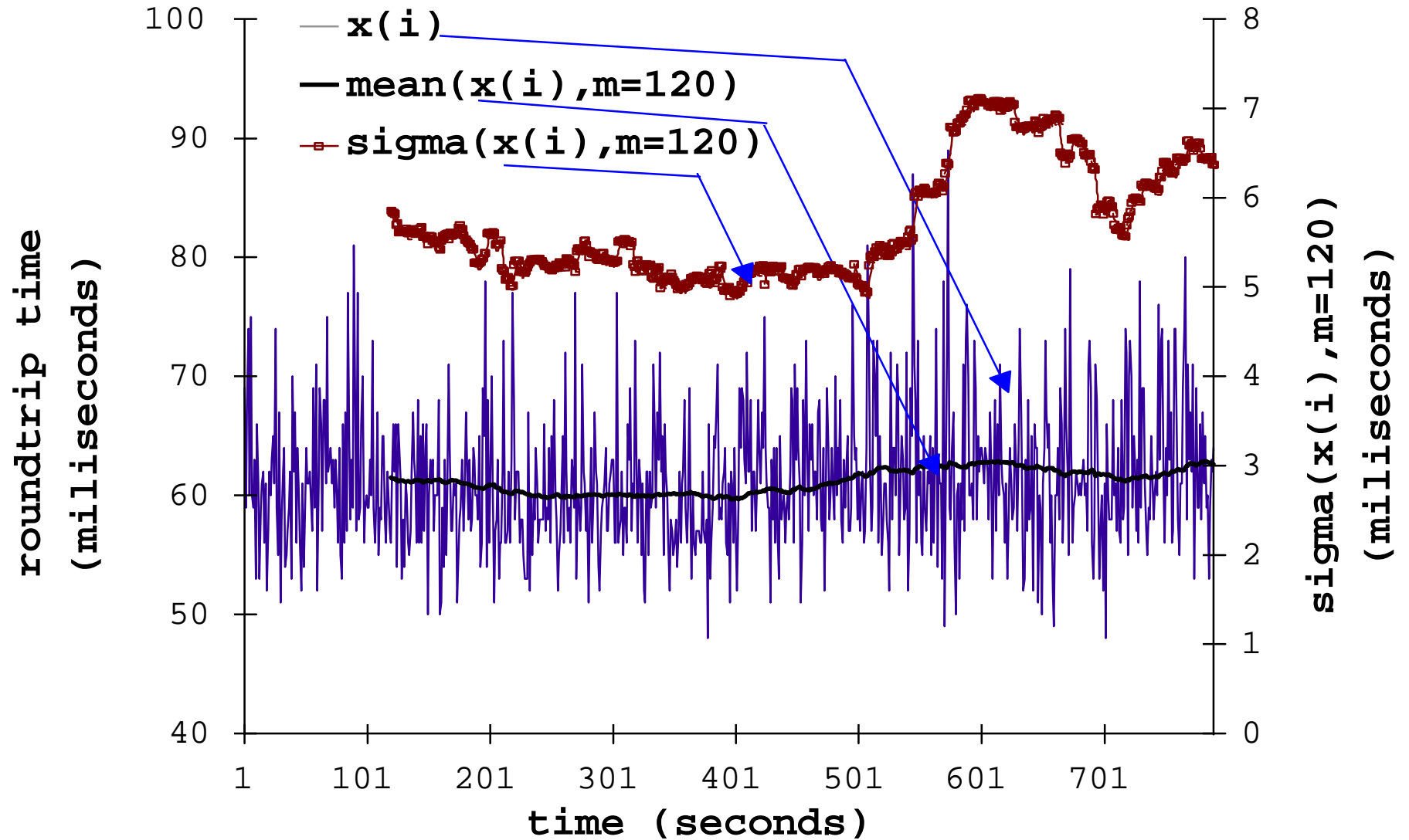
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- # Long-Term vs. Short-Term Variability



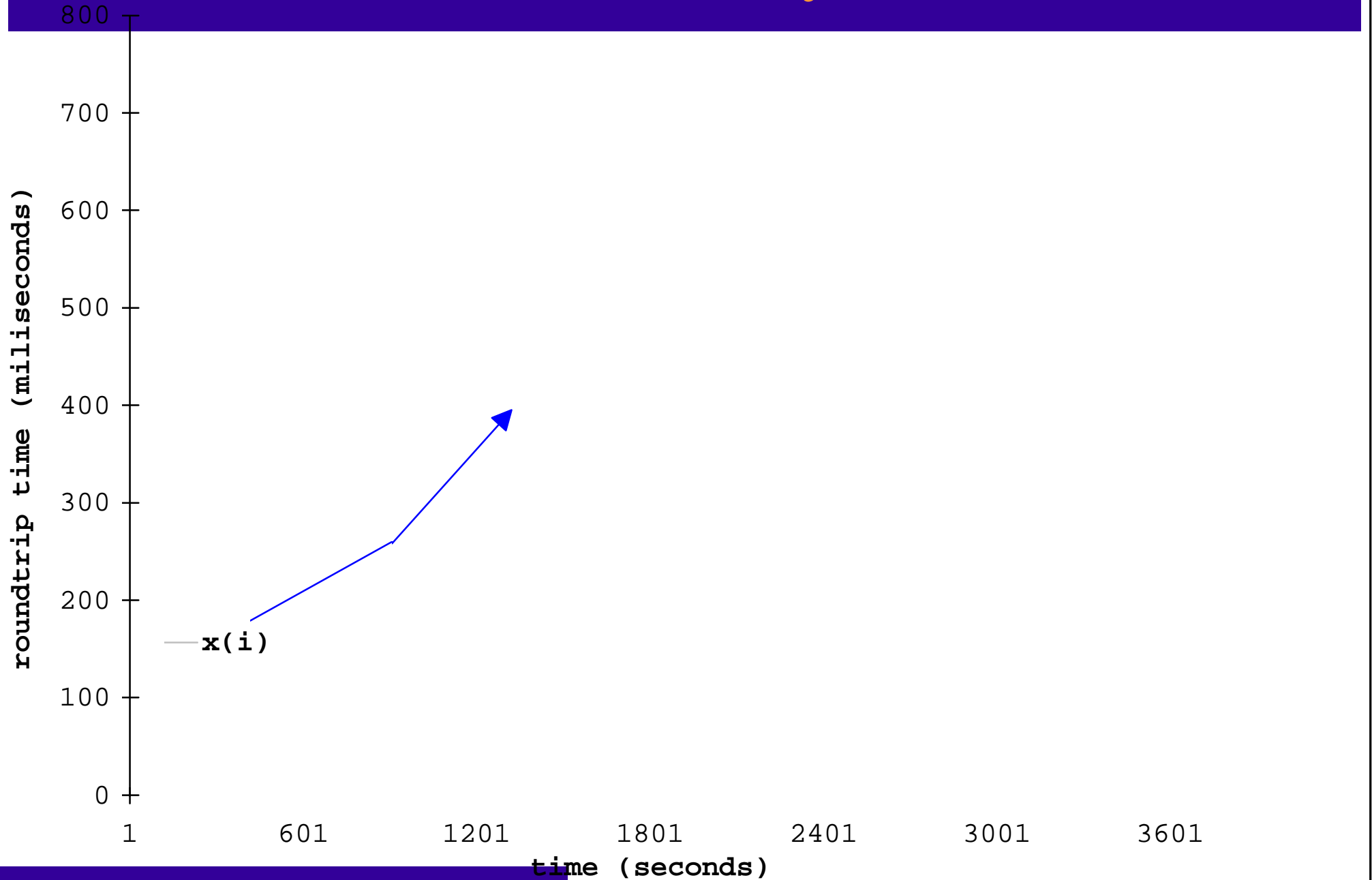
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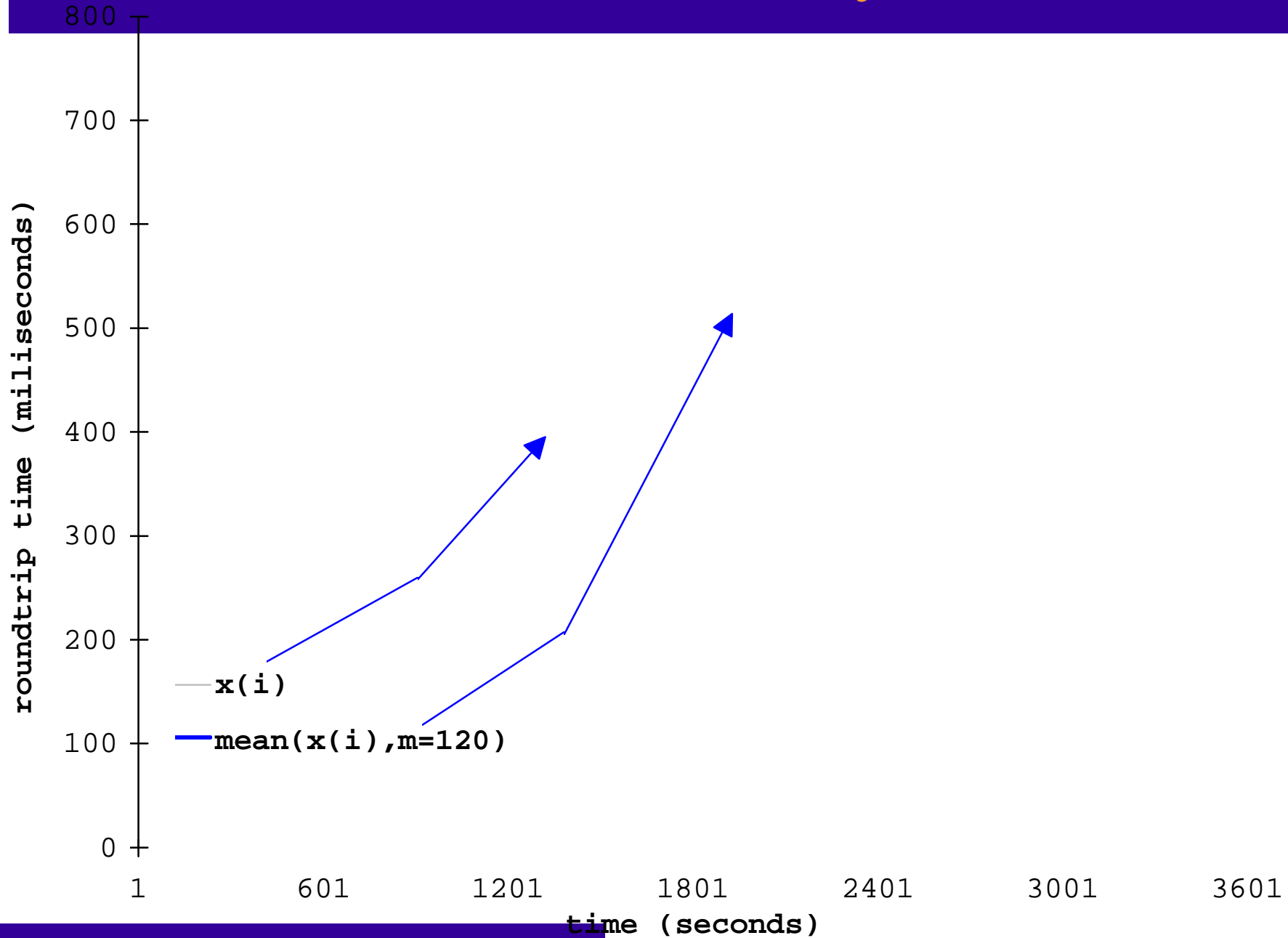
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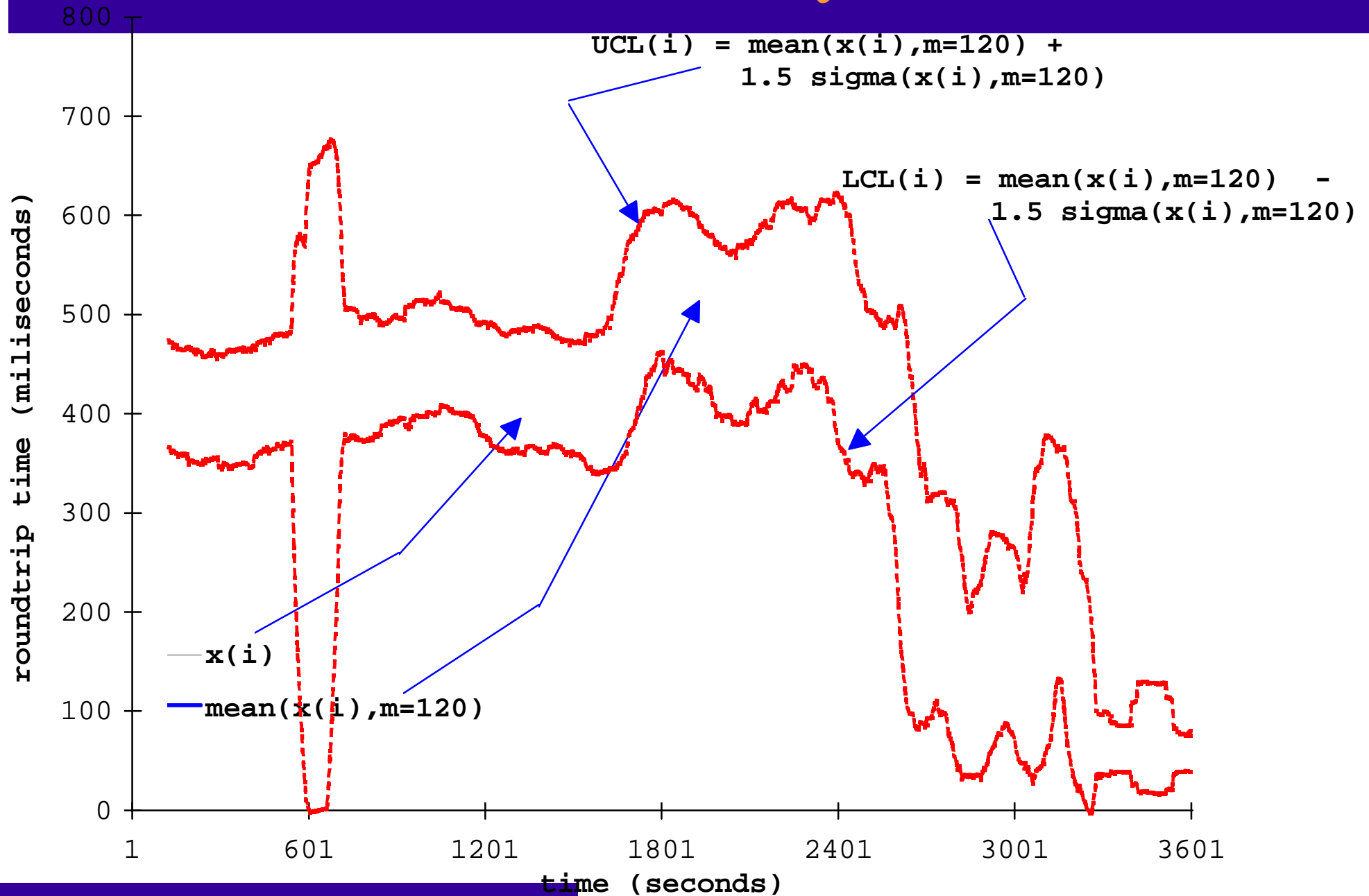
Statistical Quality Control



Statistical Quality Control



Statistical Quality Control



Statistical Process Performance (Specification of a Long-Term Monitor)

- smoothed process indicators (time scale, sampling, weights)

–BMW(x_i, m) = UWMA smoothing

$$\mu(i, m) = \mu(x_i \dots x_{m-i})$$

$$\sigma(i, m) = \mu(x_i \dots x_{m-i})$$

$$\mu(i, m') = \mu(x_i \dots x_{m'-i})$$

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- stationarity hypothesis testing

–H0 : $\mu(i, m') = \mu(i, m)$

–Z0 = $\mu(i, m') - \mu(i - m/2, m)$

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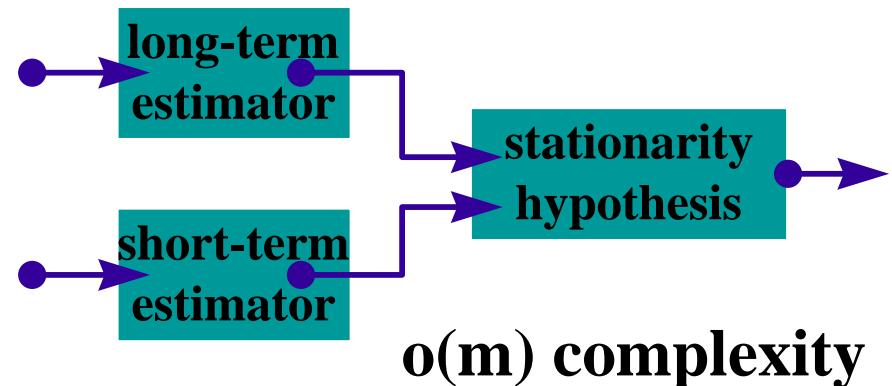
–Z0 = $\mu(i, m') - \mu(i - m/2, m)$

- confidence interval & forecast estimation

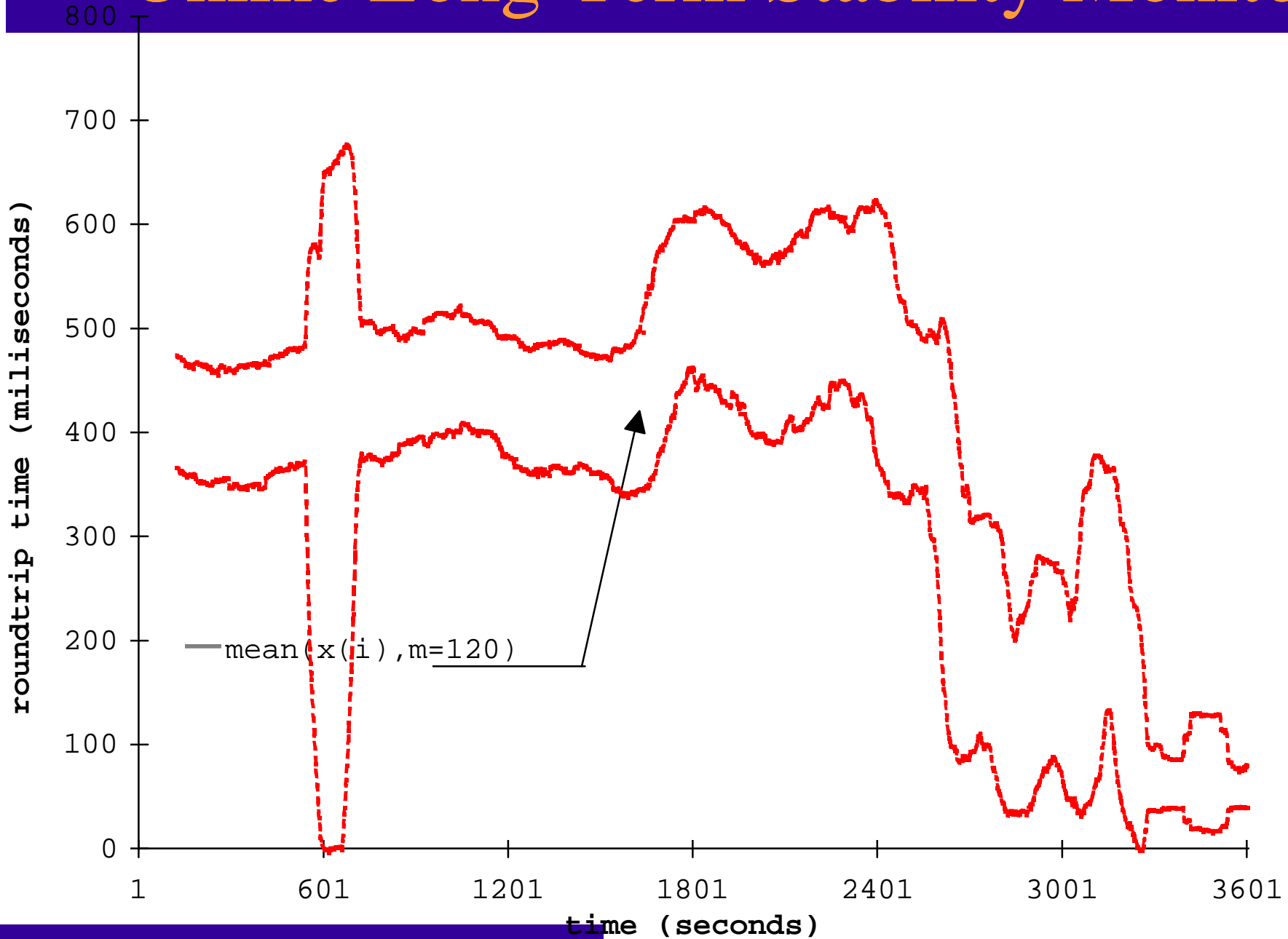
–if $|Z0| < k * \sigma(i, m)$ then $mon_i = mon_{i-1}$

–else $mon_i = \mu(i, m)$

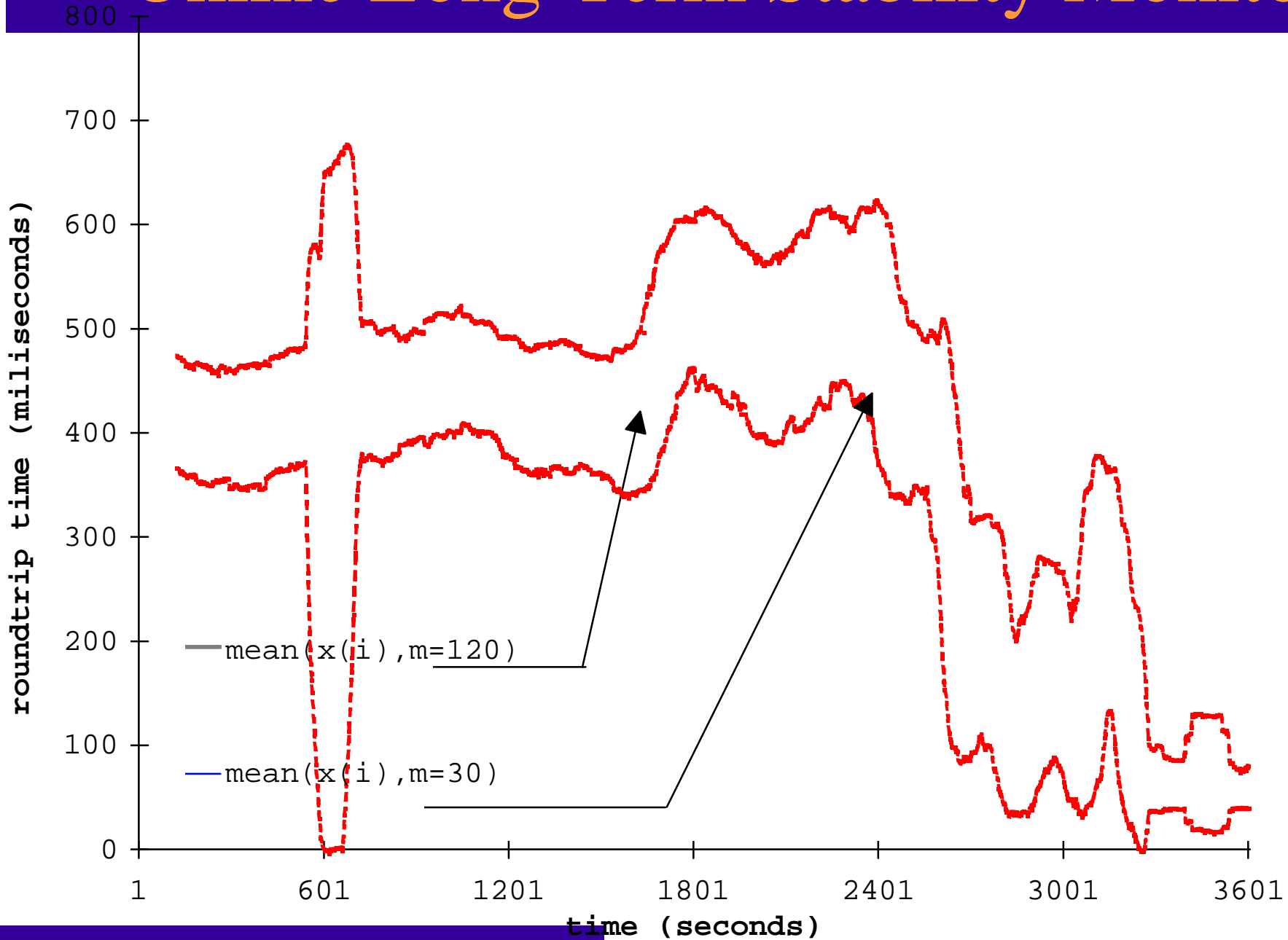
– $mon_{i+1}^* = mon_i$



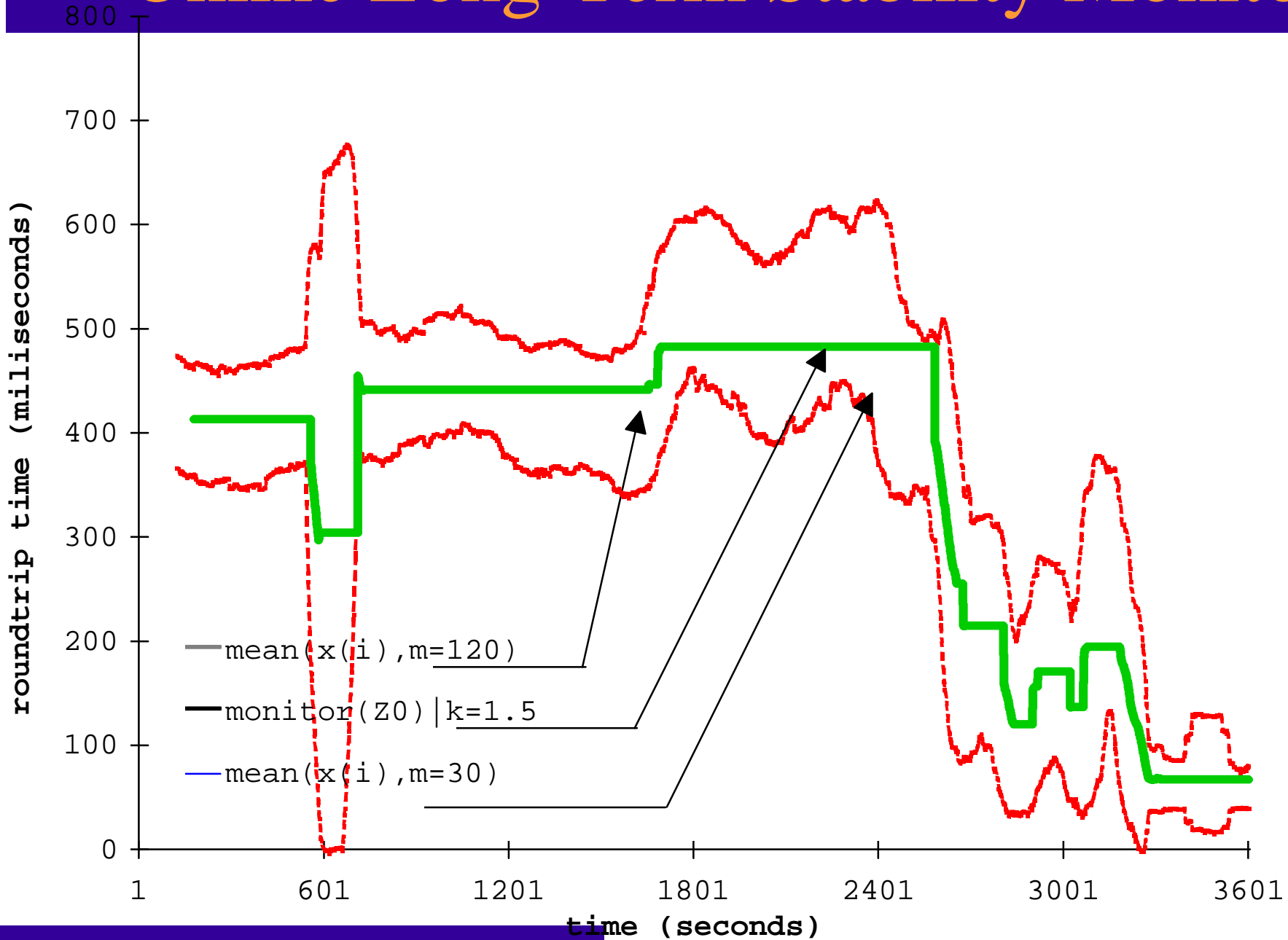
Online Long-Term Stability Monitor



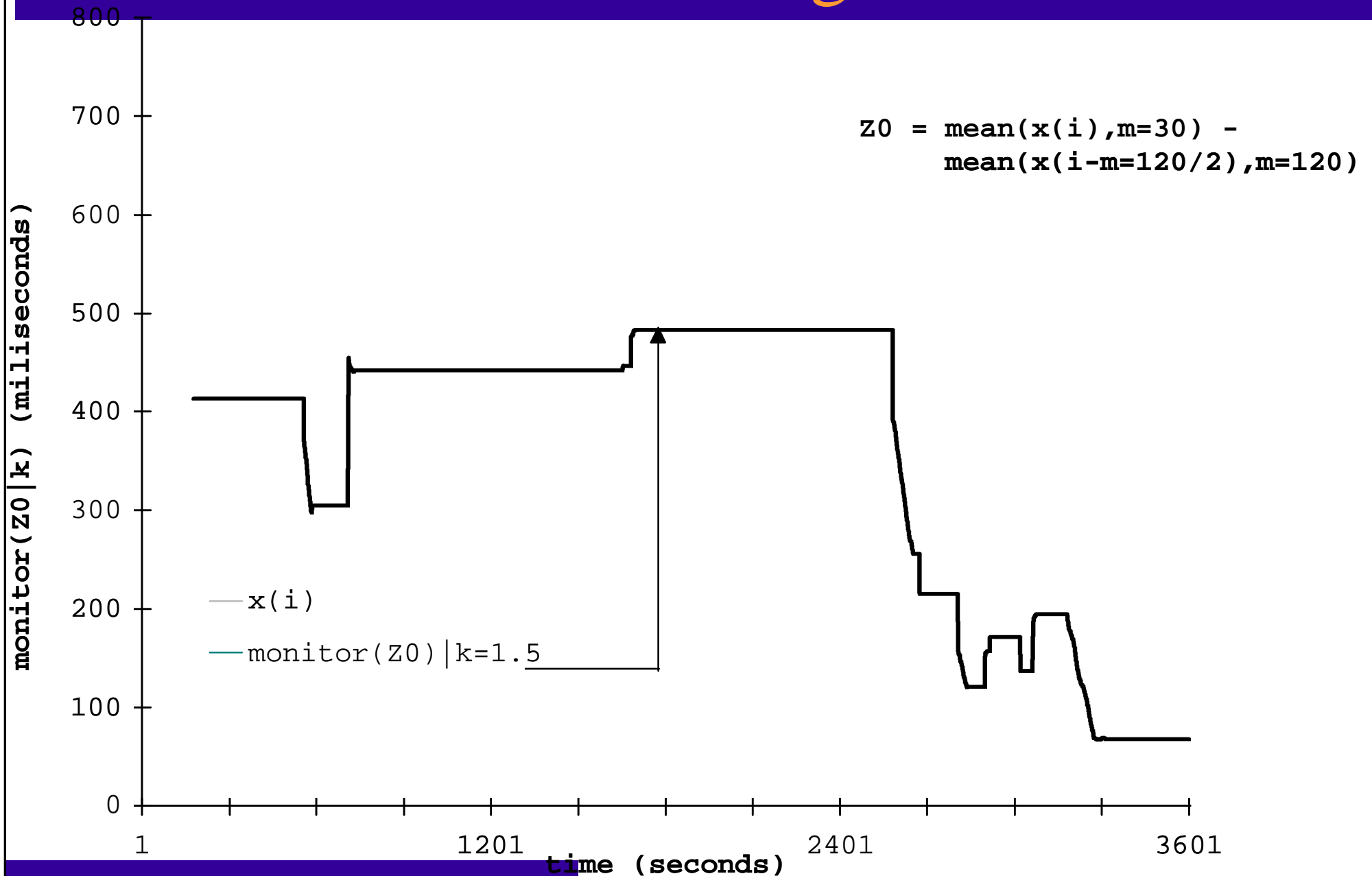
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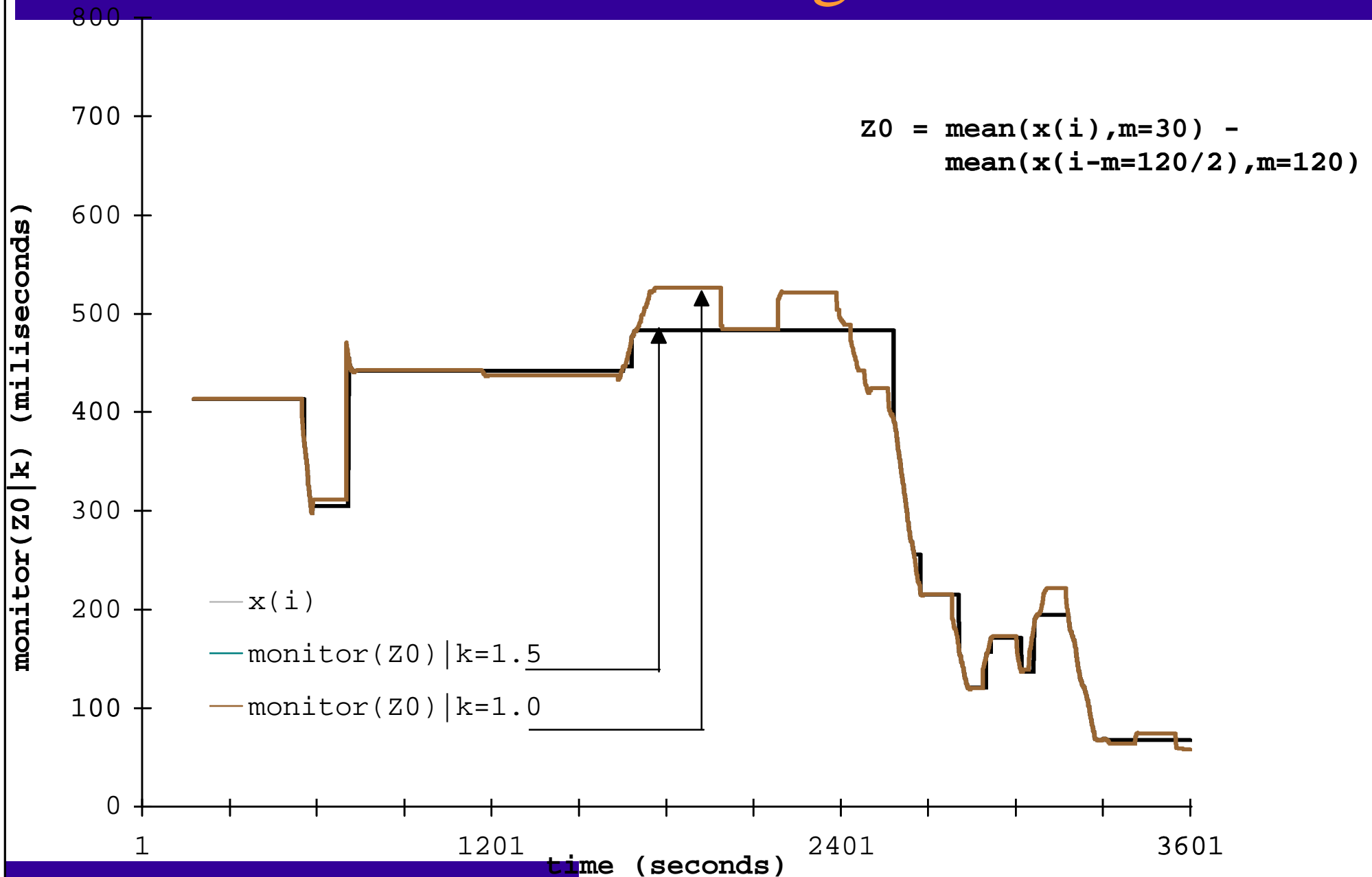
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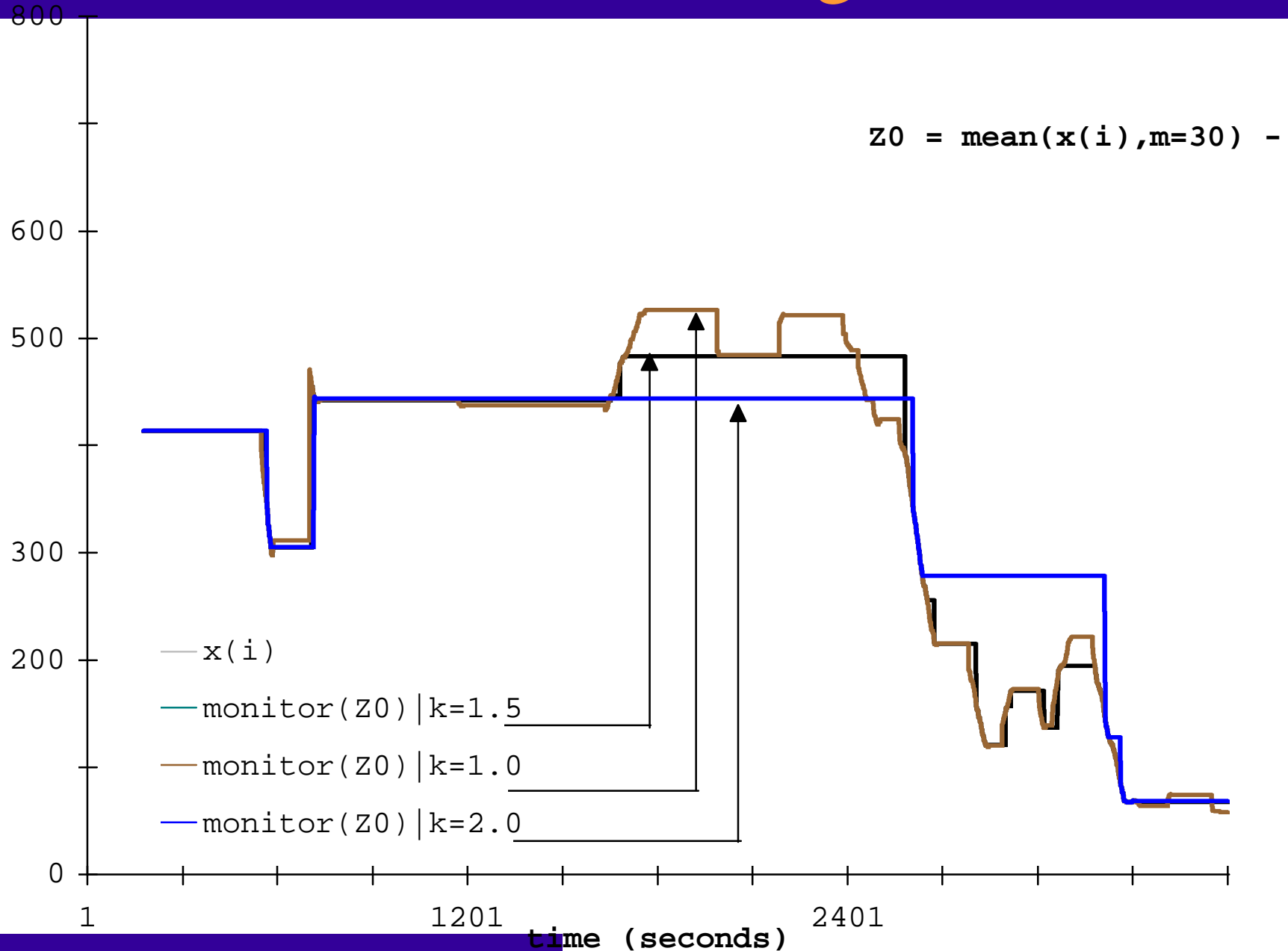
Performance of the Long-Term Monitor



Performance of the Long-Term Monitor



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- # Performance of the Long-Term Monitor



- **Statistical Process Control & Multimedia Networking**

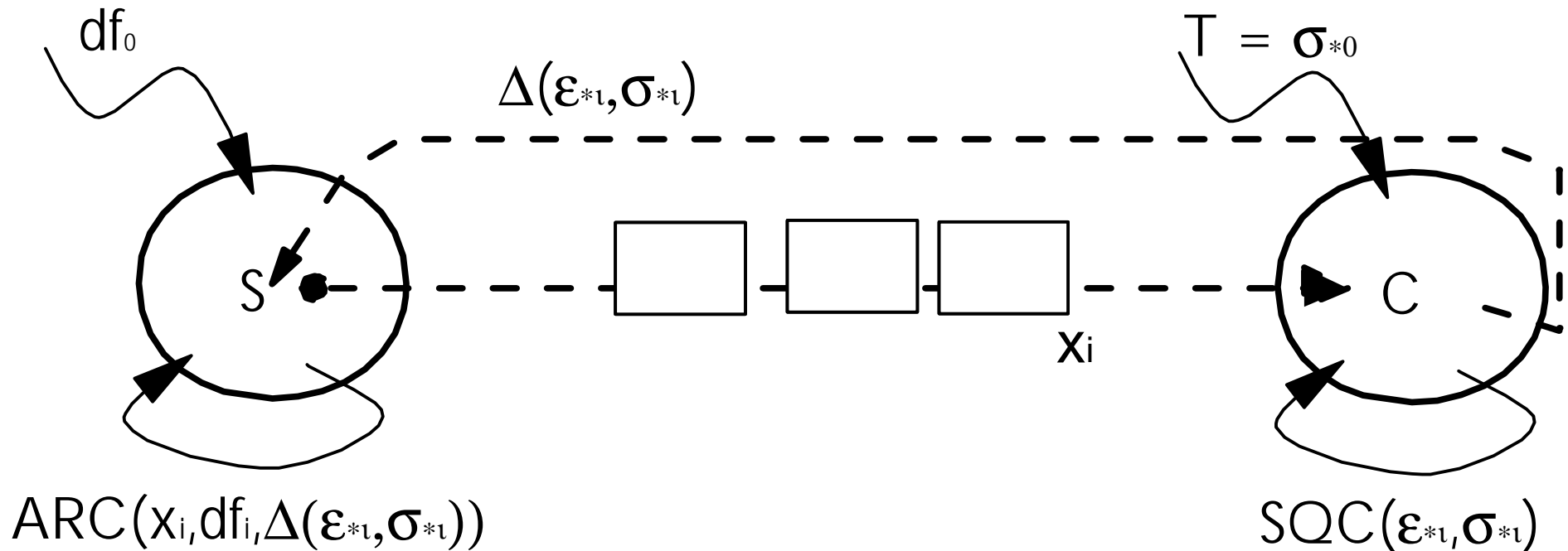
- Long-Term vs. Short-Term Variability
- Statistical Quality Control
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- **Applications of SPC to Adaptive Rate Control**

- Adaptive Media Coding/Streaming
- Adaptive Media Synchronization

- **Conclusions**

Long-Term Media Adaptation



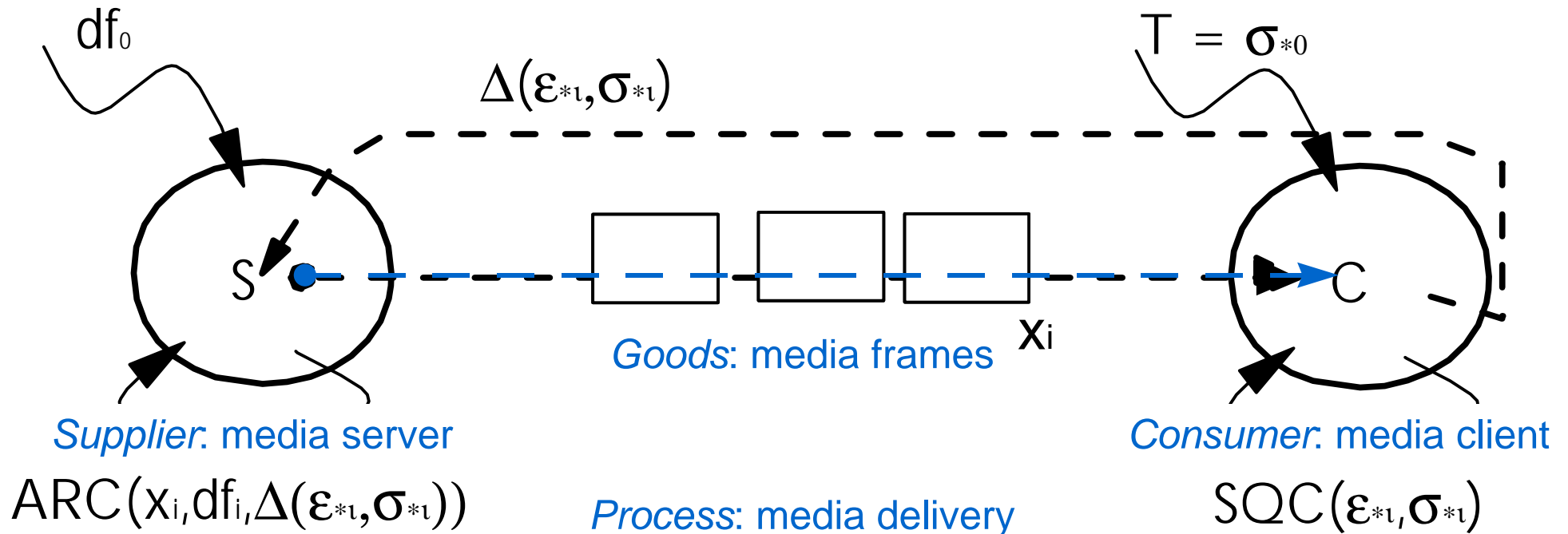
- **adaptive rate problem**

- $ARC(\text{media, degree of freedom, feedback})$

- **statistical quality control**

- $SQC(\text{process indicator, process variability})$

Long-Term Media Adaptation



- **adaptive rate problem**

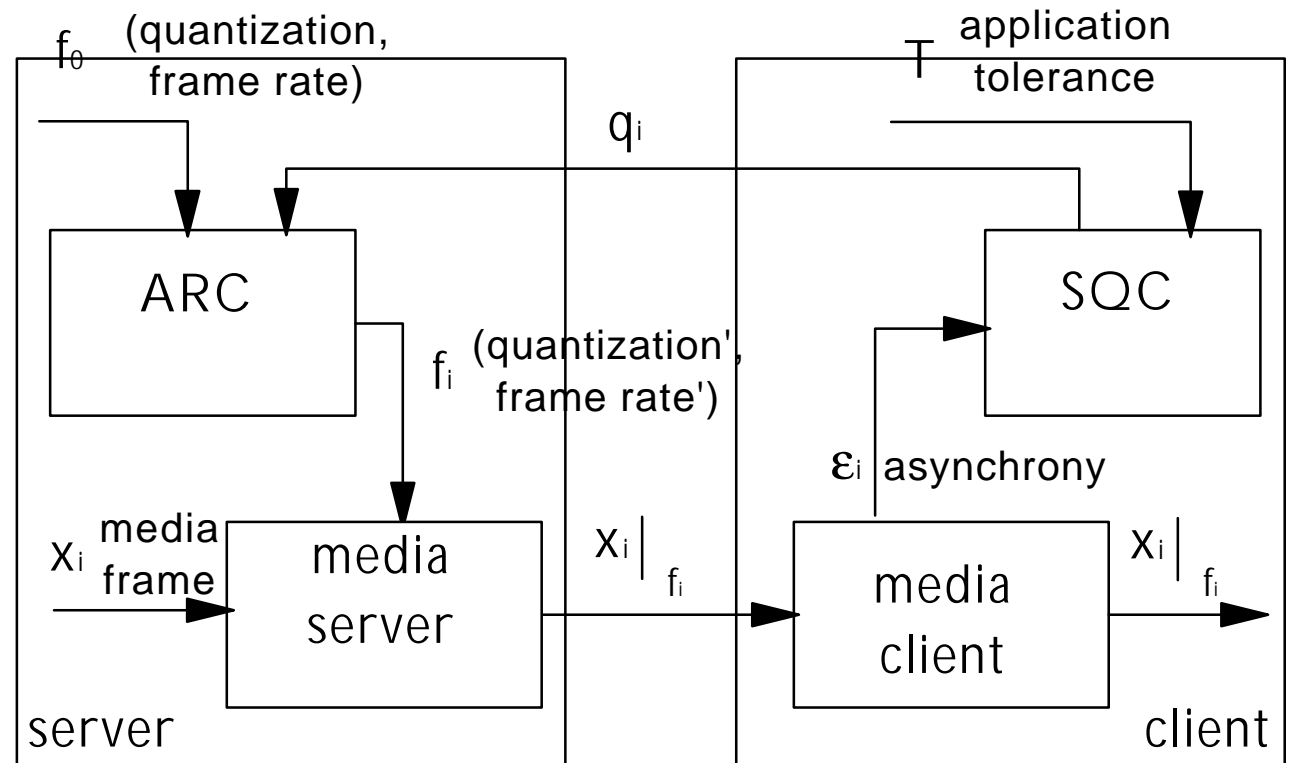
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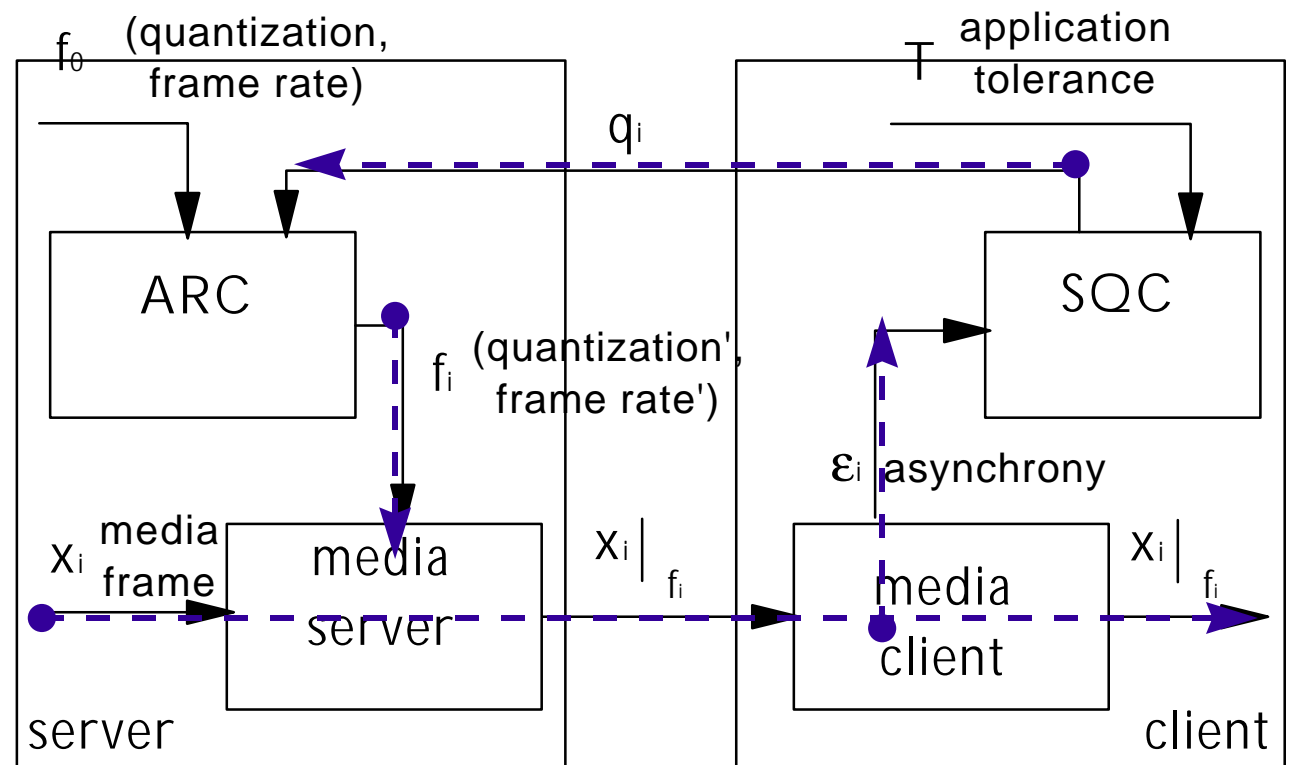
End-to-End Adaptive Media Coding

- application-oriented
- media-independent feedback
- reactive to long-term (persistent) trends

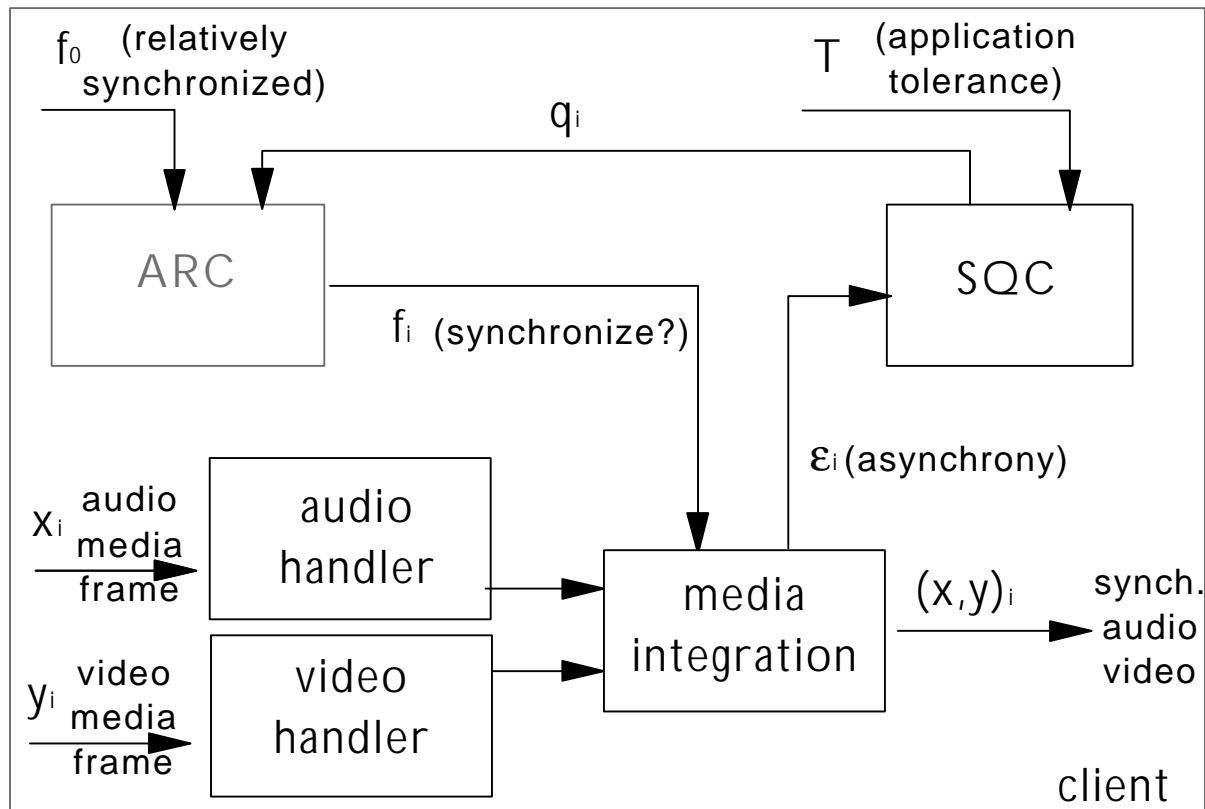


End-to-End Adaptive Media Coding

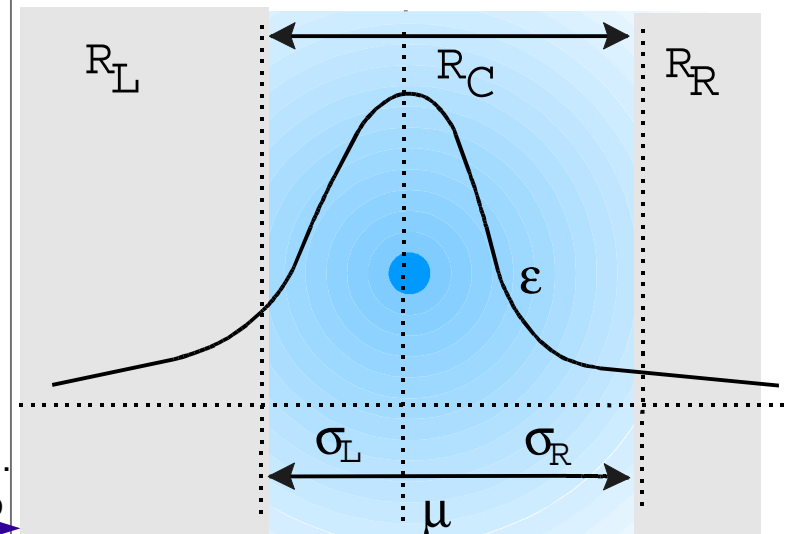
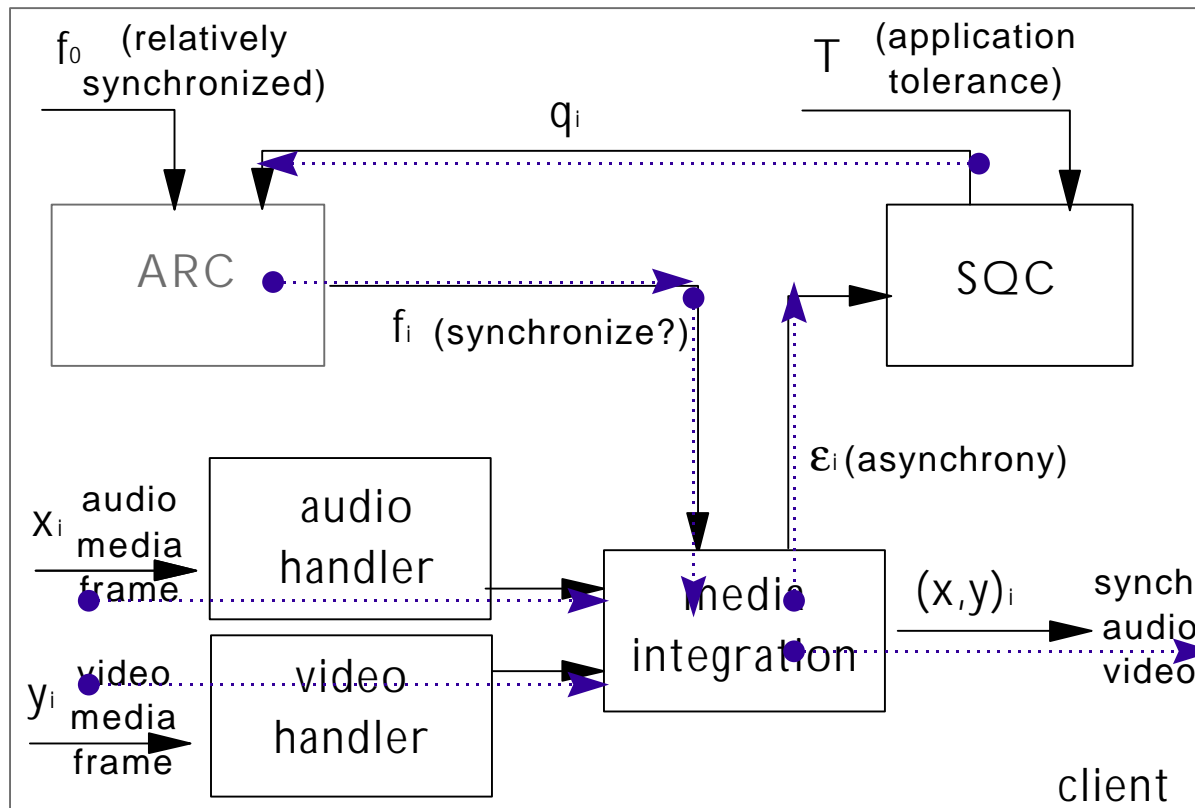
- application-oriented
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Adaptive Media Synchronization



Adaptive Media Synchronization



- **way for specifying long-term performance of its media integration in terms of tradeoffs between:**
 - the playback continuity of audio and
 - the asynchrony tolerance between audio & video.

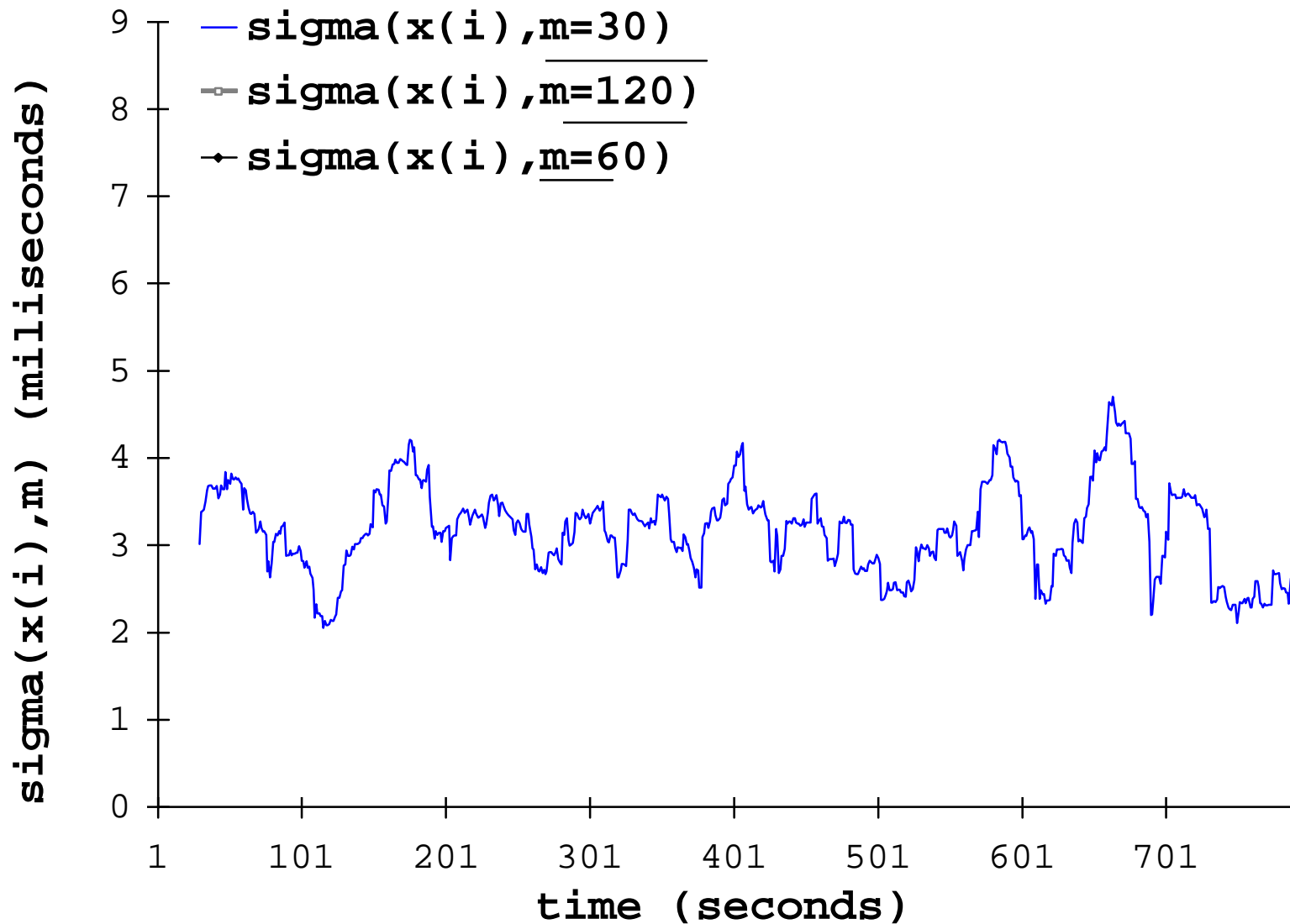
Concluding Remarks

- Introduced application and relevance of online SPC for multimedia networking
- Proposed a framework for the streaming of heterogeneous media with application-oriented requirements
- Showed the detection and forecast of long-term stationary conditions on network performance indicators

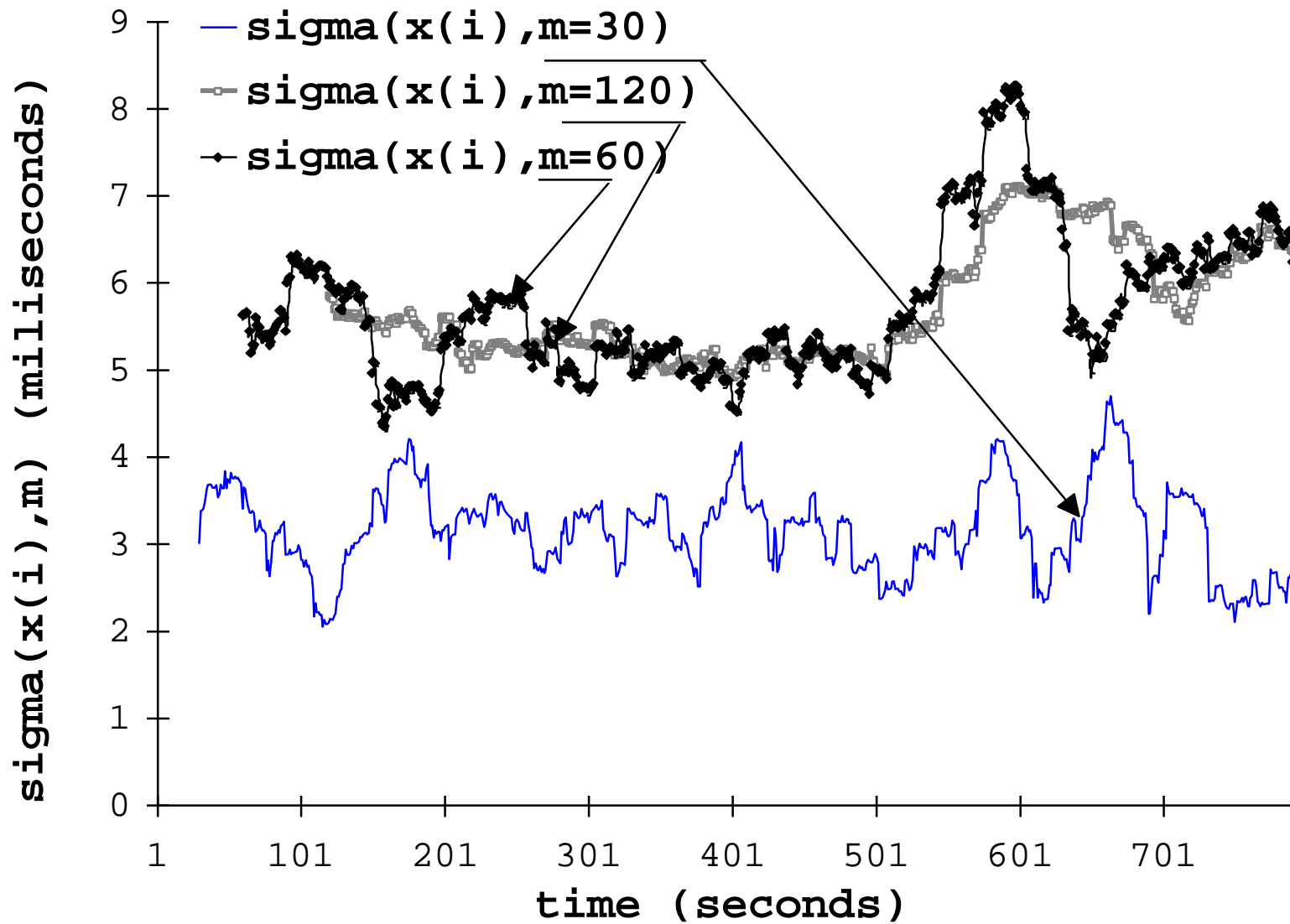
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End of Presentation

Long-Term Process Performance



Long-Term Process Performance



Assumptions

- **distribution of samples**
 - UWMA smoothed over large horizon
 - central limit theorem ... “roughly” normal
- **autocorrelation between smoothers**
 - sampling frequency between measurements
 - time scale of smoothers (approx. random sampling)
 - relative weight horizons of smoothers (m and m')
- **stationarity**
 - hypothesis testing discards random fluctuations
 - variance prediction confidence over forecast