Using and Extending LIMBO for Descriptive Modeling of Arrival Behaviors

Symposium on Software Performance

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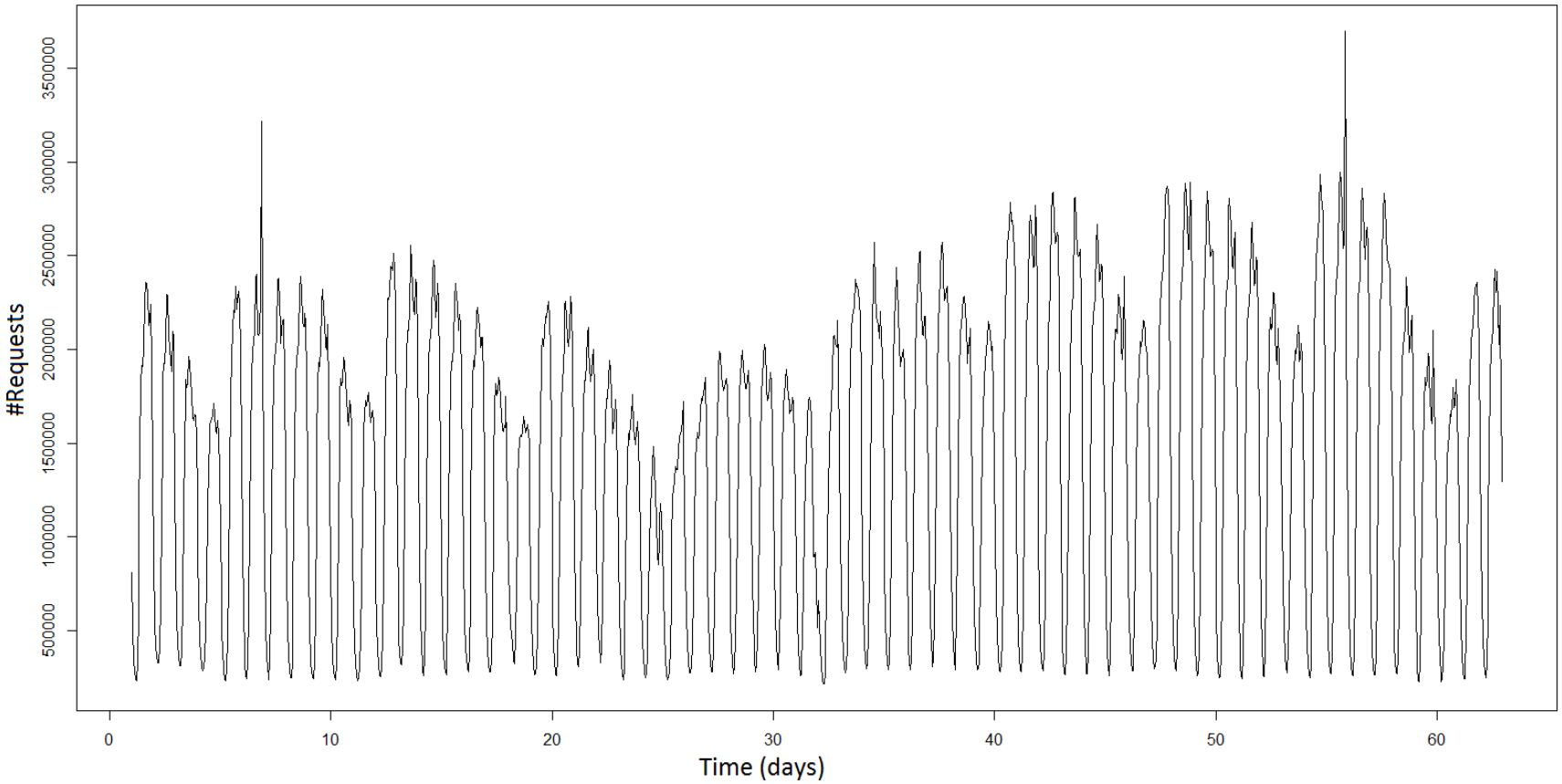
Motivation

- Page Requests for the German Wikipedia



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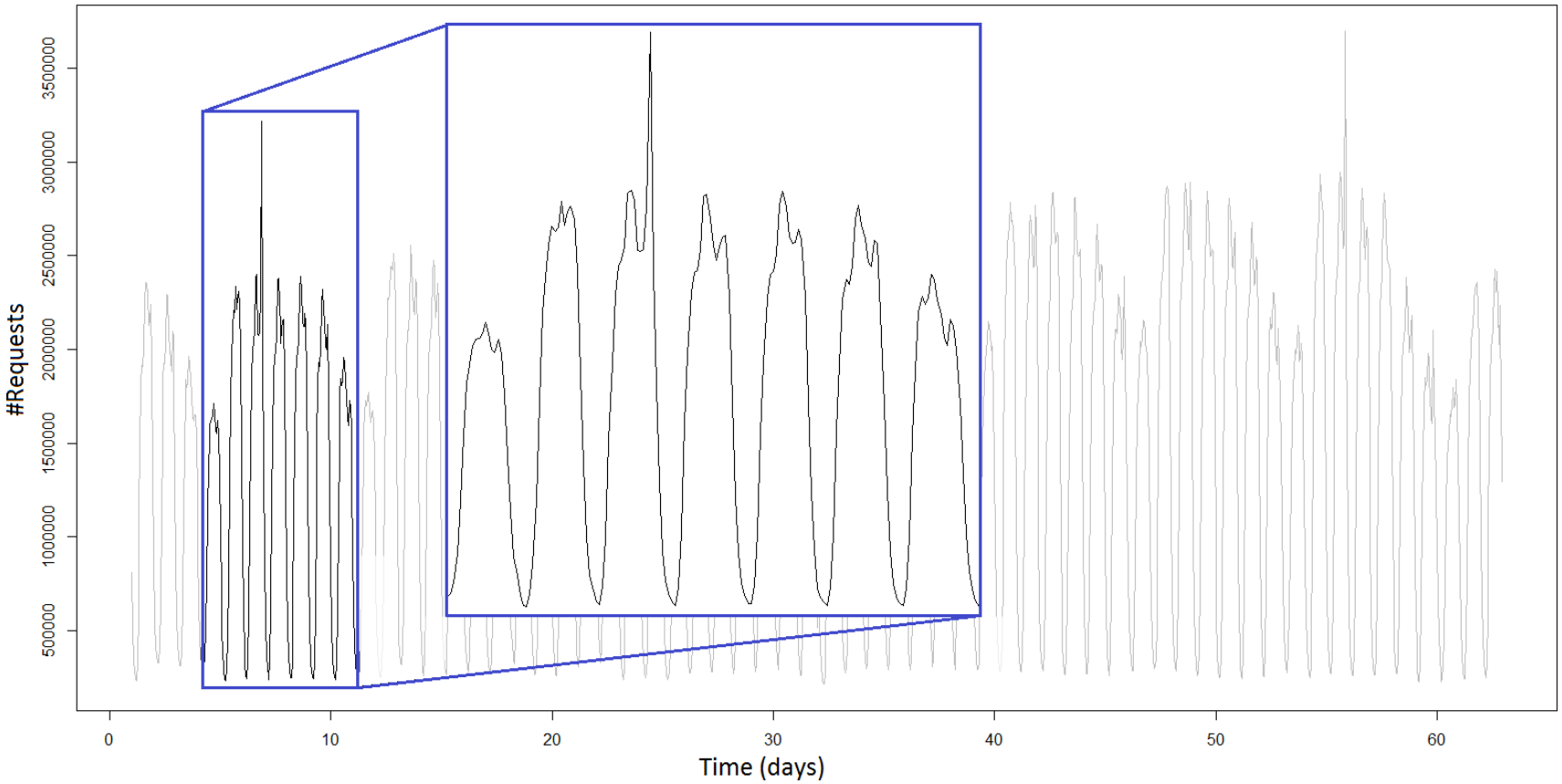

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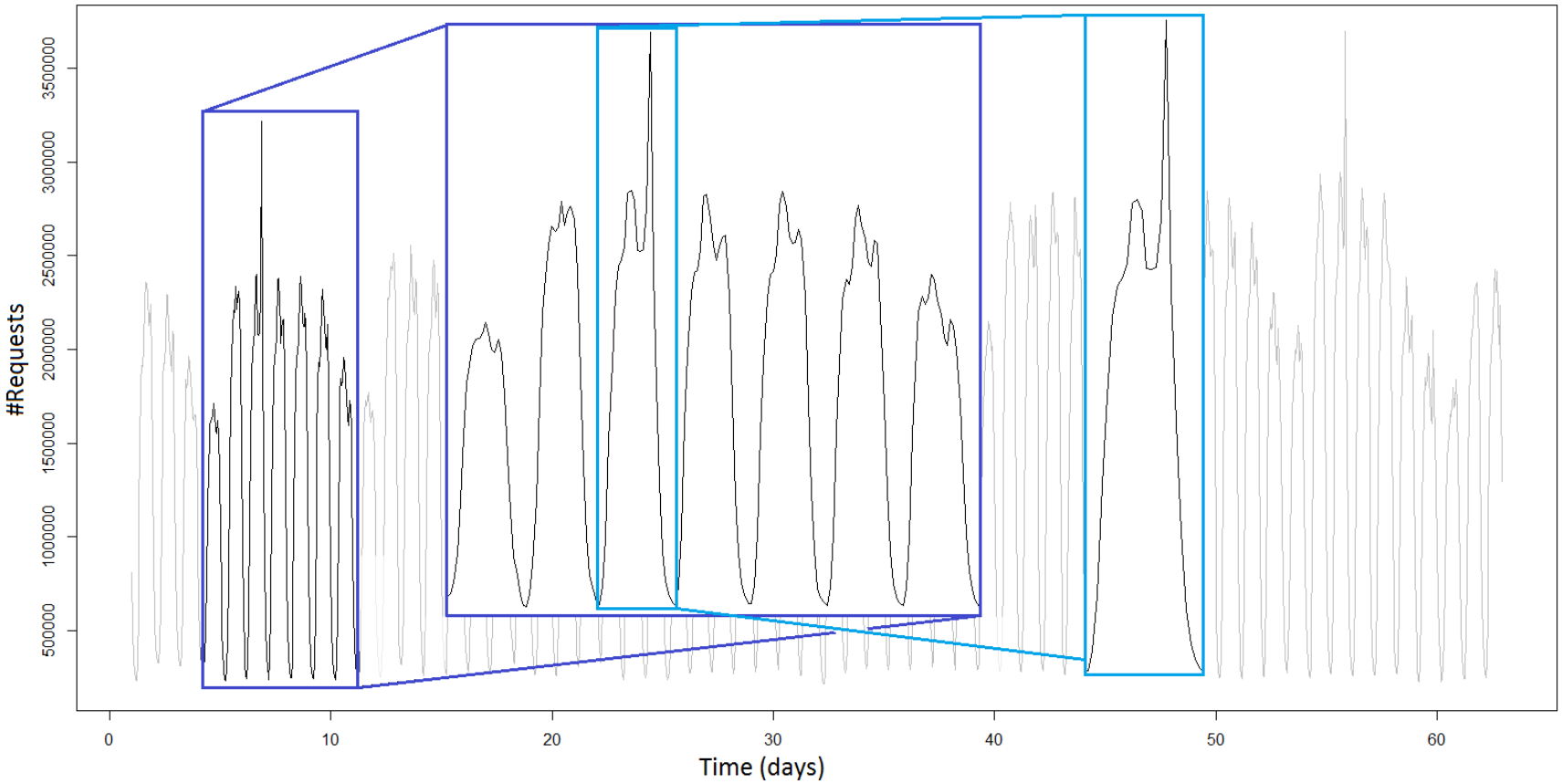

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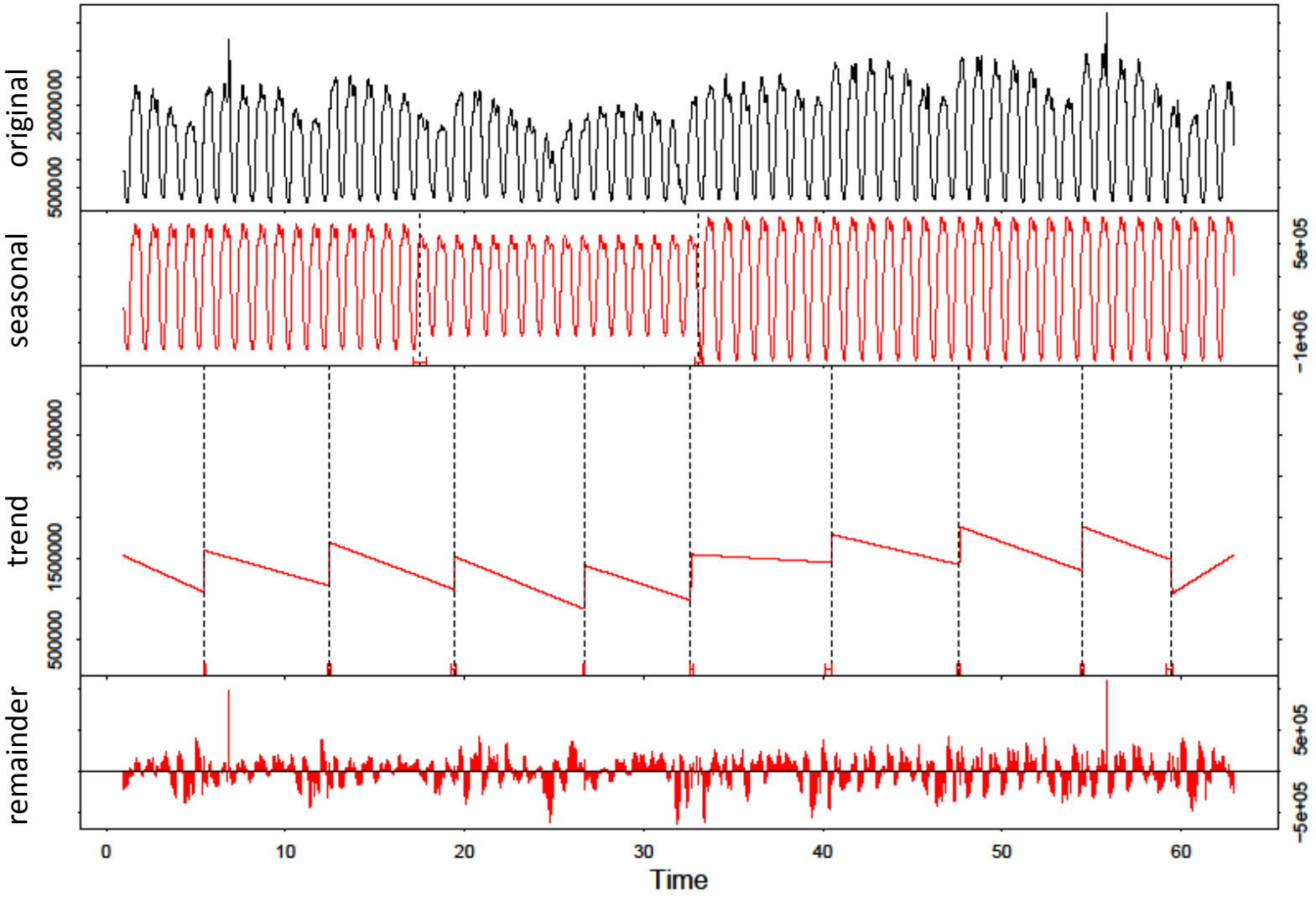


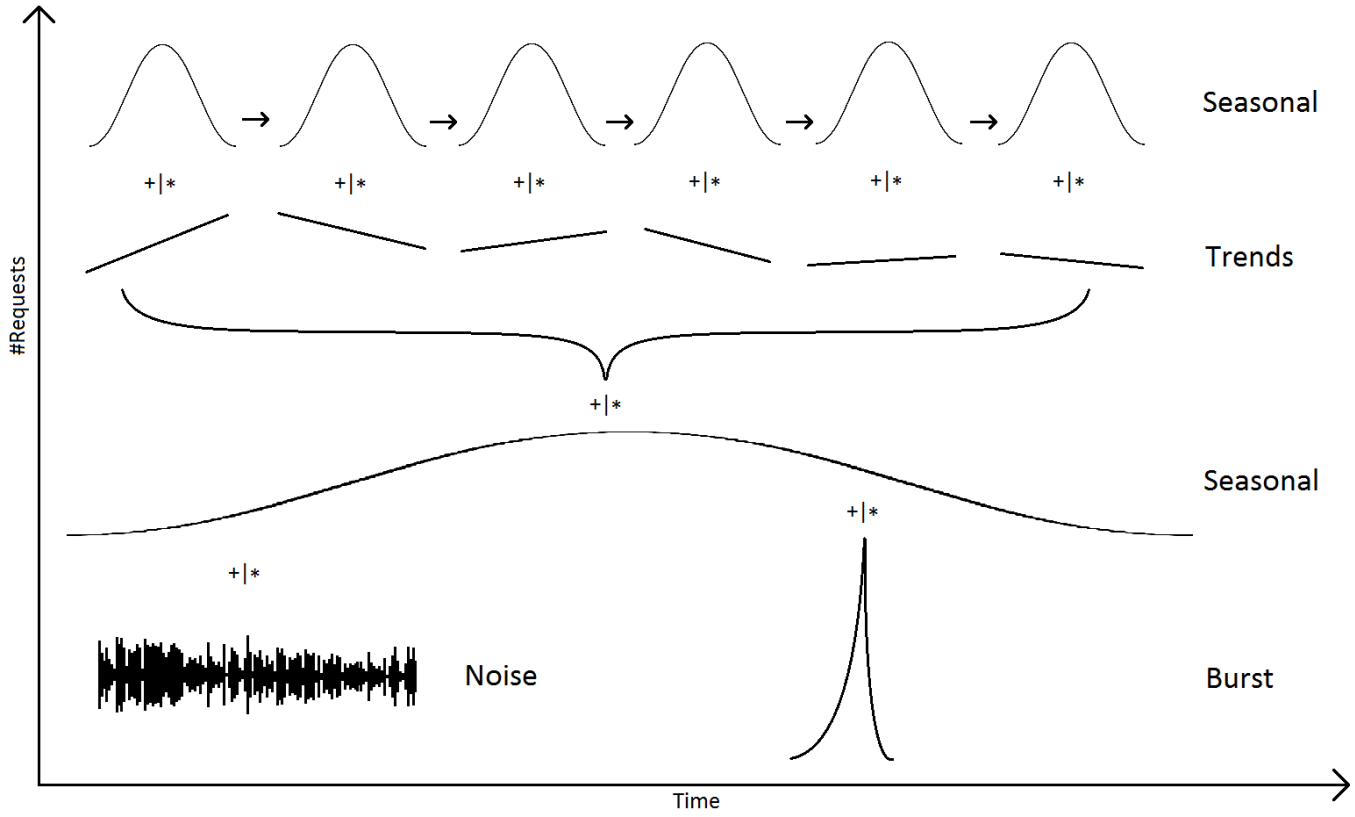
Additive decomposition into seasonal part, trend, and remainder. Created using *BFAST* [1].

Outline

- **Problem:** No means to effectively capture, reproduce, and modify varying load intensity of real-world cloud systems
- **Idea:** Support load intensity profile description by creating a meta-model and tooling
- **Benefits:** Enable more precise communication and creation of realistic load scenarios for benchmarking
- **Actions:** Creation of meta-models, processes, and tools for load intensity extraction and description

Descartes Load Intensity Model (DLIM)

- Describes arrival rate variations over time
- Provides structure for piece-wise mathematical functions
- Independent of work/request type

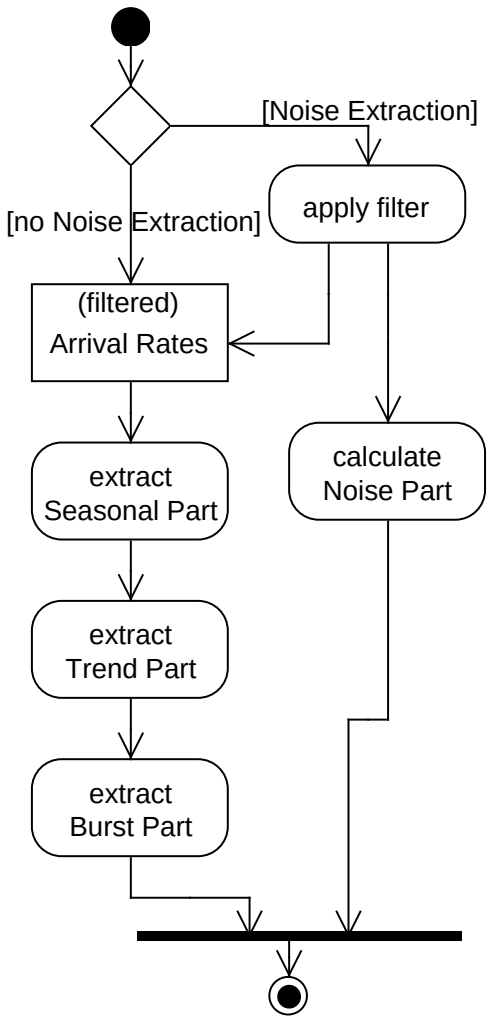


high-level DLIM

- Benefits of DLIM:
  - Powerful and expressive
  - Easy derivation of arrival rates or request time-stamps
- Drawbacks of DLIM:
  - Instances can become complex
  - Large trees may be unintuitive
- Solution: **high-level DLIM**
  - Fewer parameters for load intensity profile description
  - Strictly structured into single *Seasonal*, *Trend*, recurring *Burst*, and *Noise* parts

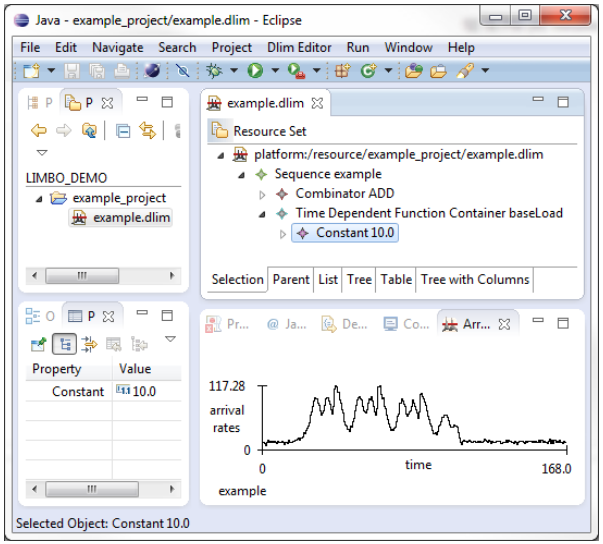
Automated Model Instance Extraction

- Automated process for extracting DLIM or hl-DLIM instances from existing arrival rate traces
- Structured into *Seasonal*, *Trend*, *Burst*, and *Noise* part extraction
- Noise reduction and extraction is optional and separate



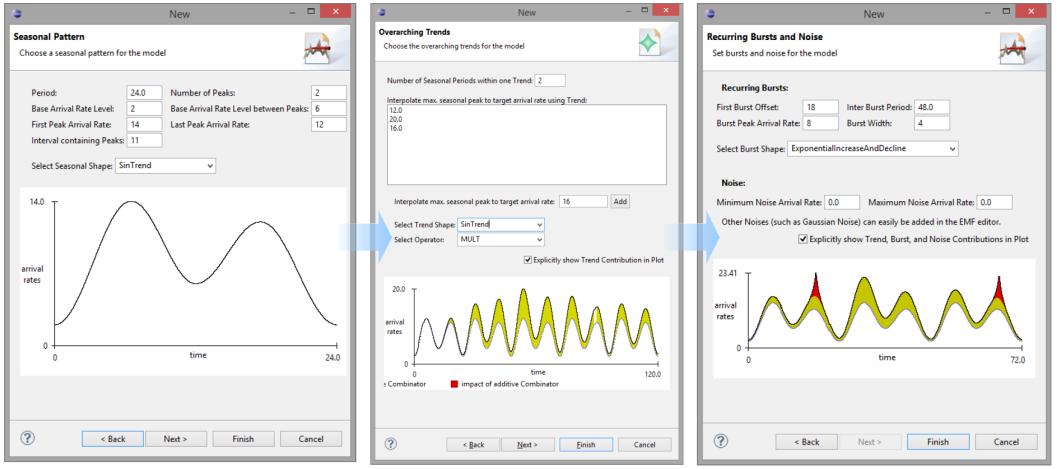
LIMBO

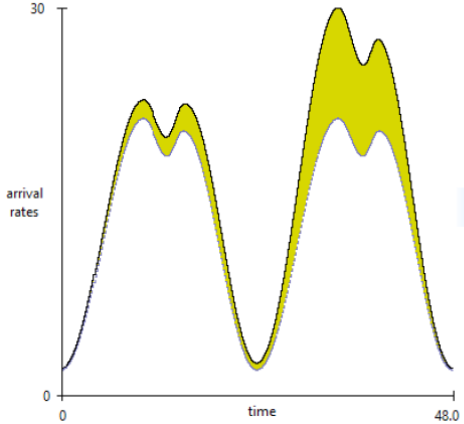
- EMF-based modeling platform
- Uses DLIM for load intensity description
- New Model Creation Wizard based on hl-DLIM
- Allows arrival rate and request time-stamp generation
  - Can be used in JMeter using the TimestampTimer by Andreas Weber (KIT)[a]
- Visualizes and compares arrival rate profiles
- Provides automated model instance extraction

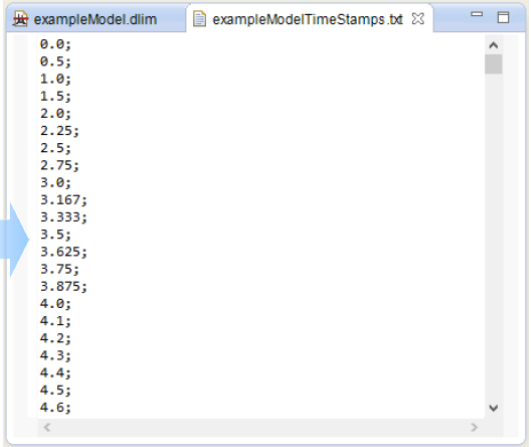


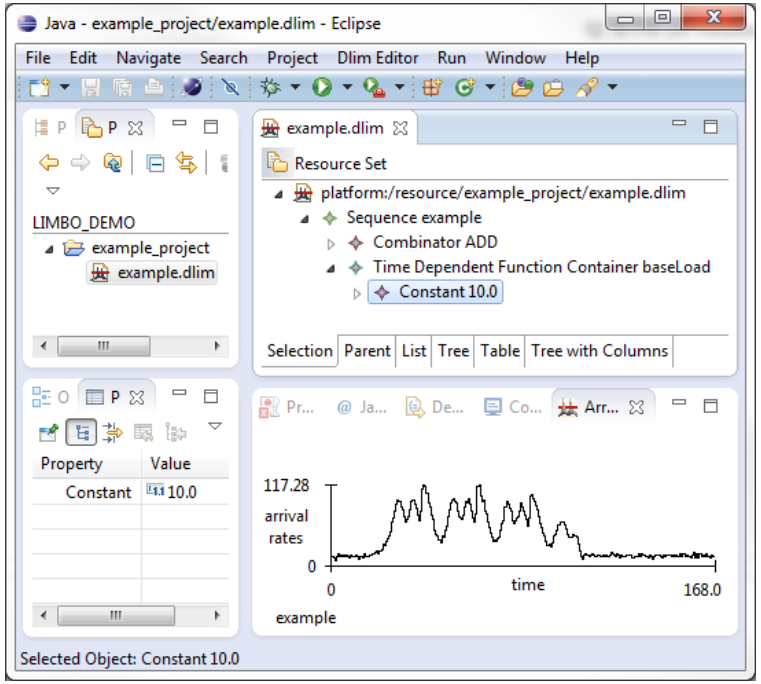
[a] LIMBO: `https://github.com/andreaswe/JMeterTimestampTimer`

LIMBO Demonstration









Evaluation

- **Usability Evaluation**
  - Usability evaluated using a questionnaire
  - Users are computer scientists from five different organizations
  - Mean Usability (1 = easy, 4 = difficult): **1.44**
  - Mean Feature Usefulness (1 = useful, 4 = not useful): **1.2**
- **Model Extraction Accuracy Evaluation**
  - 9 real world web server traces
  - Metric: median arrival rate deviation
  - S-MIEP and hl-MIEP applied to all traces
  - P-MIEP to traces longer than one month

S-MIEP

Trace	S-MIEP relative median error (%)	BFAST relative median error (%)
ClarkNet-HTTP	12.409	12.243
NASA-HTTP	18.812	-
Saskatchewan-HTTP	26.492	-
WorldCup98	12.979	-
IBM Transactions	29.199	-
de.wikipedia.org	8.538	11.223
fr.wikipedia.org	7.6	8.511
ru.wikipedia.org	9.912	5.809
wikipedia.org	4.855	2.302

- S-MIEP performs on average **8354** times faster than BFAST

Summary

- Two Meta-Models for load intensity variation description
  - **DLIM:** Powerful and expressive
  - **hl-DLIM:** Abstract and concise
- Modeling Platform: **LIMBO**
  - Enables creation of custom load intensity variations for open workload based benchmarking
  - Provides automated load intensity profile extraction
- Automated model instance extraction:
  - **S-MIEP**: most accurate, median deviation: 12.4%
  - **P-MIEP**: good for regular profiles, median deviation: 37.6%
  - **hl-MIEP**: relies on noise reduction, median deviation: 15.6%
- LIMBO is open-source[1] and already being used in different contexts.

[1] LIMBO: `http://descartes.tools/limbo`

Thank you for your Interest!

- Our future work on LIMBO:
  - Extraction of multiple and overlaying seasonal patterns
  - Change detection
  - Advanced calibration and noise reduction
- Ideas for integration/extension
  - Extending Markov4JMeter to use LIMBO timestamps
  - Extending PCM and DML to use DLIM instances or LIMBO timestamps
  - Using DLIM models for improving anomaly detection accuracy

References

J. Verbesselt, R. Hyndman, G. Newnham, and D. Culvenor, "Detecting trend and seasonal changes in satellite image time series," *Remote Sensing of Environment*, vol. 114, no. 1, pp. 106 – 115, 2010. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S003442570900265X