University of Stuttgart
Institute of Software Technology
Reliable Software Systems

State of the Art of Visualization in APM Tools

André van Hoorn
Dušan Okanović

Tutorial @ Visualizing Systems and Software Performance (VSSP)
July 10, 2018. Dagstuhl, Germany

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Part 1/2: Introduction to APM

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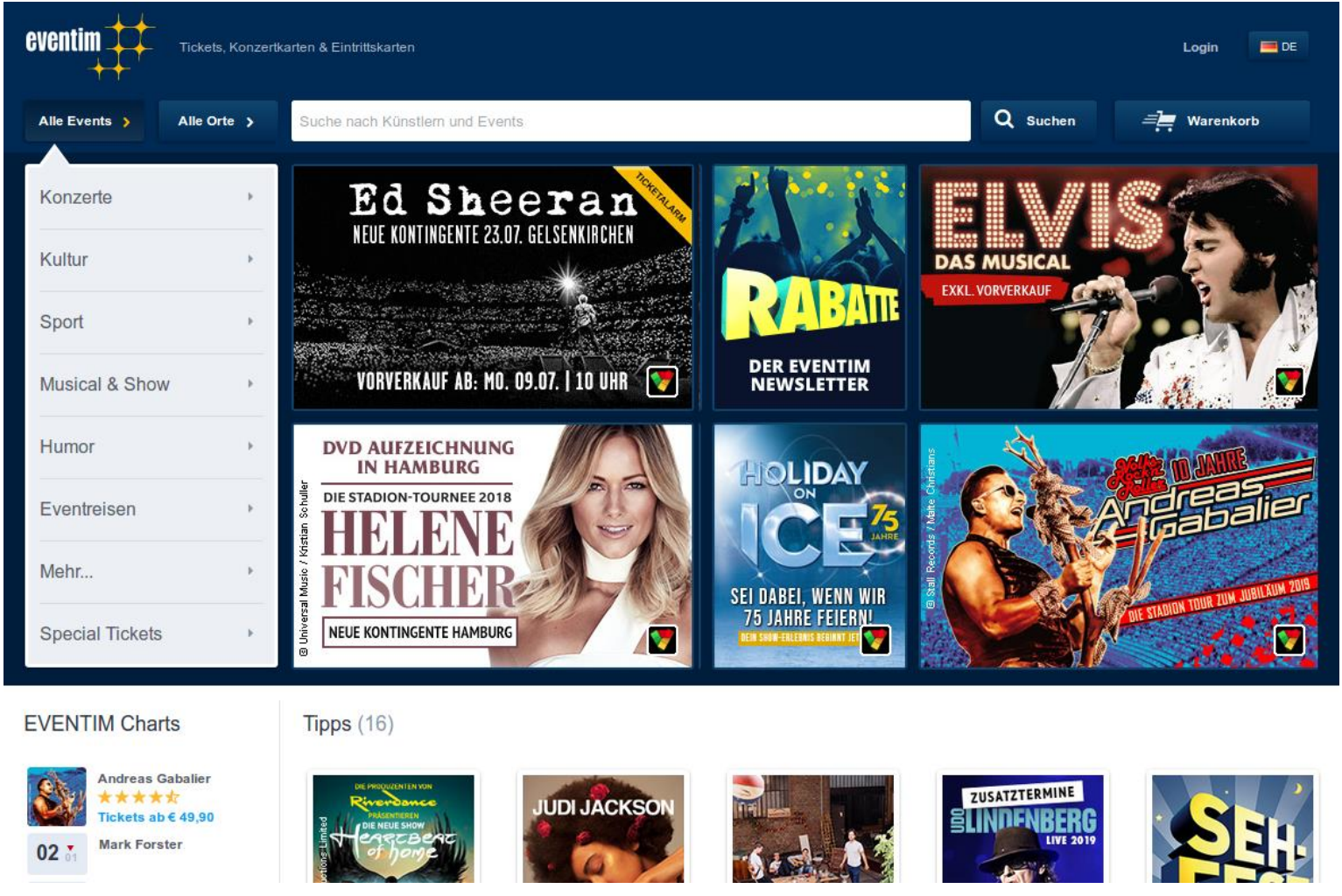

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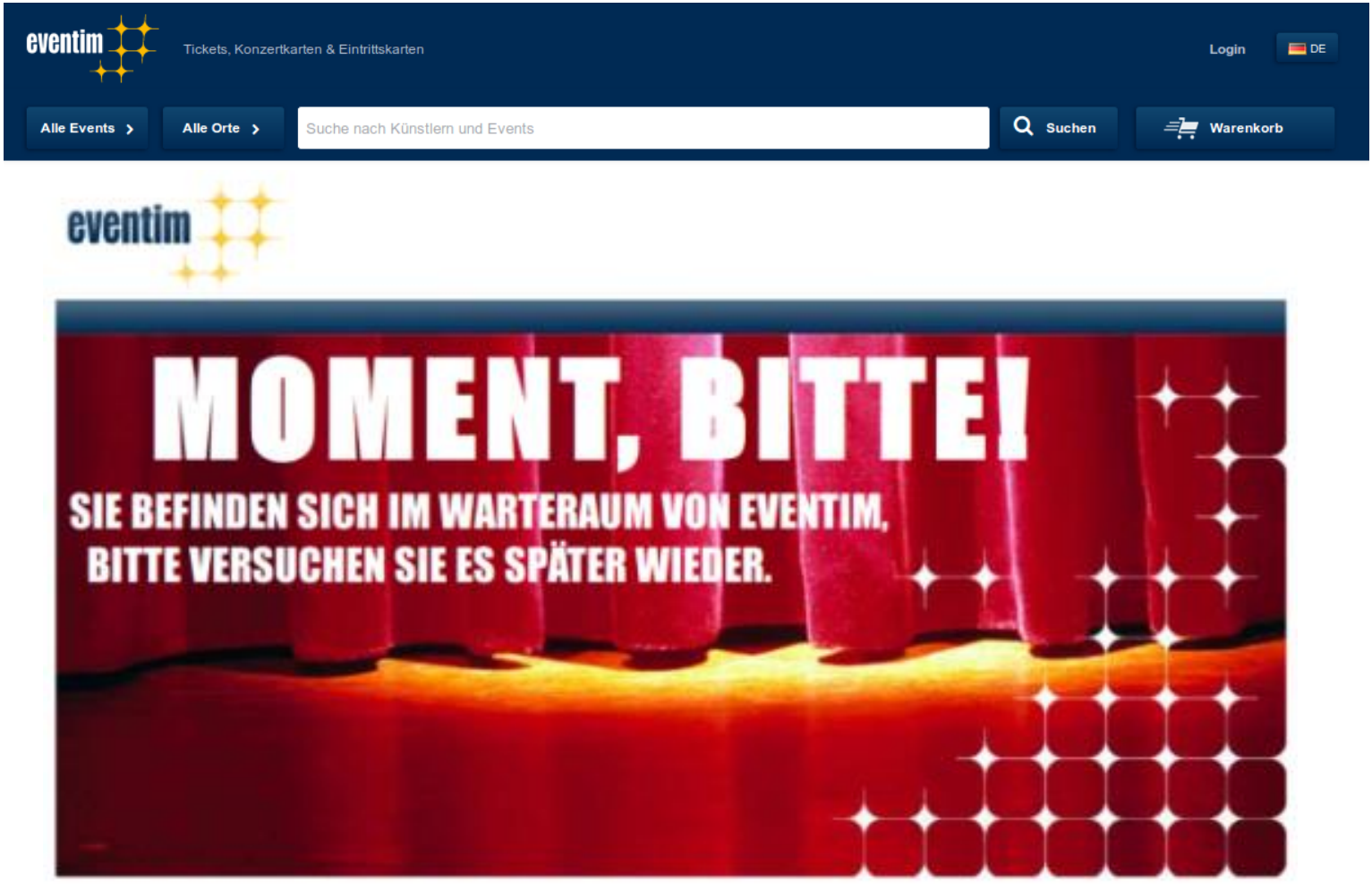
Künstler-Biografie

Otto Gerhard Waalkes, häufig einfach nur Otto genannt, (* 22. Juli 1948 in Emden) ist ein deutscher Komiker, Comiczeichner, Musiker, Schauspieler, Regisseur und Synchronsprecher. Der gebürtige Ostfriese gilt als einer der erfolgreichsten Vertreter des deutschen Humors. Im Jahr 2007 kam Otto Waalkes bei der Wahl zum besten deutschsprachigen Komiker ...

weiterlesen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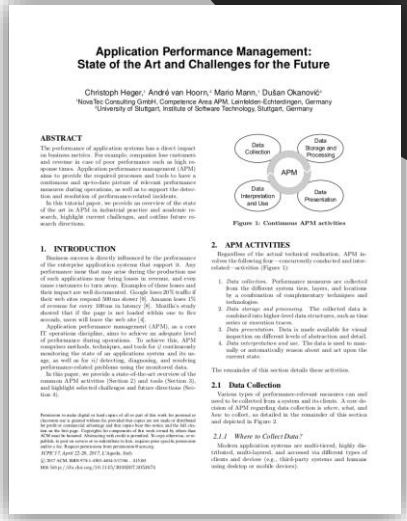
“Application performance management (APM), as a core IT operations discipline, aims to **achieve an adequate level of performance during operations**. To achieve this,

APM comprises **methods, techniques, and tools** for

- **continuously monitoring** the state of an application system and its usage, as well as for
- **detecting, diagnosing, and resolving performance-related problems** using the monitored data.”



Application Performance Management:
State of the Art and Challenges for the Future

Christoph Heger,[1] André van Hoorn,[2] Mario Mann,[1] Dušan Okanović[2]
[1]NovaTec Consulting GmbH, Competence Area APM, Leinfelden-Echterdingen, Germany
[2]University of Stuttgart, Institute of Software Technology, Stuttgart, Germany

ABSTRACT

The performance of application systems has a direct impact on business metrics. For example, companies lose customers and revenue in case of poor performance such as high response times. Application performance management (APM) aims to provide the required processes and tools to have a continuous and up-to-date picture of relevant performance measures during operations, as well as to support the detection and resolution of performance-related incidents.

In this tutorial paper, we provide an overview of the state of the art in APM in industrial practice and academic research, highlight current challenges, and outline future research directions.

1. INTRODUCTION

Business success is directly influenced by the performance of the enterprise application systems that support it. Any performance issue that may arise during the production use of such applications may bring losses in revenue, and even cause customers to turn away. Examples of those losses and their impact are well-documented. Google loses 20% traffic if their web sites respond 500 ms slower [9]. Amazon loses 1% of revenue for every 100 ms in latency [8]. MindBox's study showed that if the page is not loaded within one to five seconds, users will leave the web site [4].

Application performance management (APM), as a core IT operations discipline, aims to achieve an adequate level of performance during operations. To achieve this, APM comprises methods, techniques, and tools for 1) continuously monitoring the state of an applications system and its usage, as well as for 2) detecting, diagnosing, and resolving performance-related problems using the monitored data.

In this paper, we provide a state-of-the-art overview of the common APM activities (Section 2) and tools (Section 3), and highlight selected challenges and future directions (Section 4).

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DOI: http://dx.doi.org/10.1145/3030207.3053674

Figure 1: Continuous APM activities

2. APM ACTIVITIES

Regardless of the actual technical realization, APM involves the following four—concurrently conducted and interrelated—activities (Figure 1):

1. *Data collection.* Performance measures are collected from the different system tiers, layers, and locations by a combination of complementary techniques and technologies.
2. *Data storage and processing.* The collected data is combined into higher-level data structures, such as time series or execution traces.
3. *Data presentation.* Data is made available for visual inspection on different levels of abstraction and detail.
4. *Data interpretation and use.* The data is used to manually or automatically reason about and act upon the current state.

The remainder of this section details these activities.

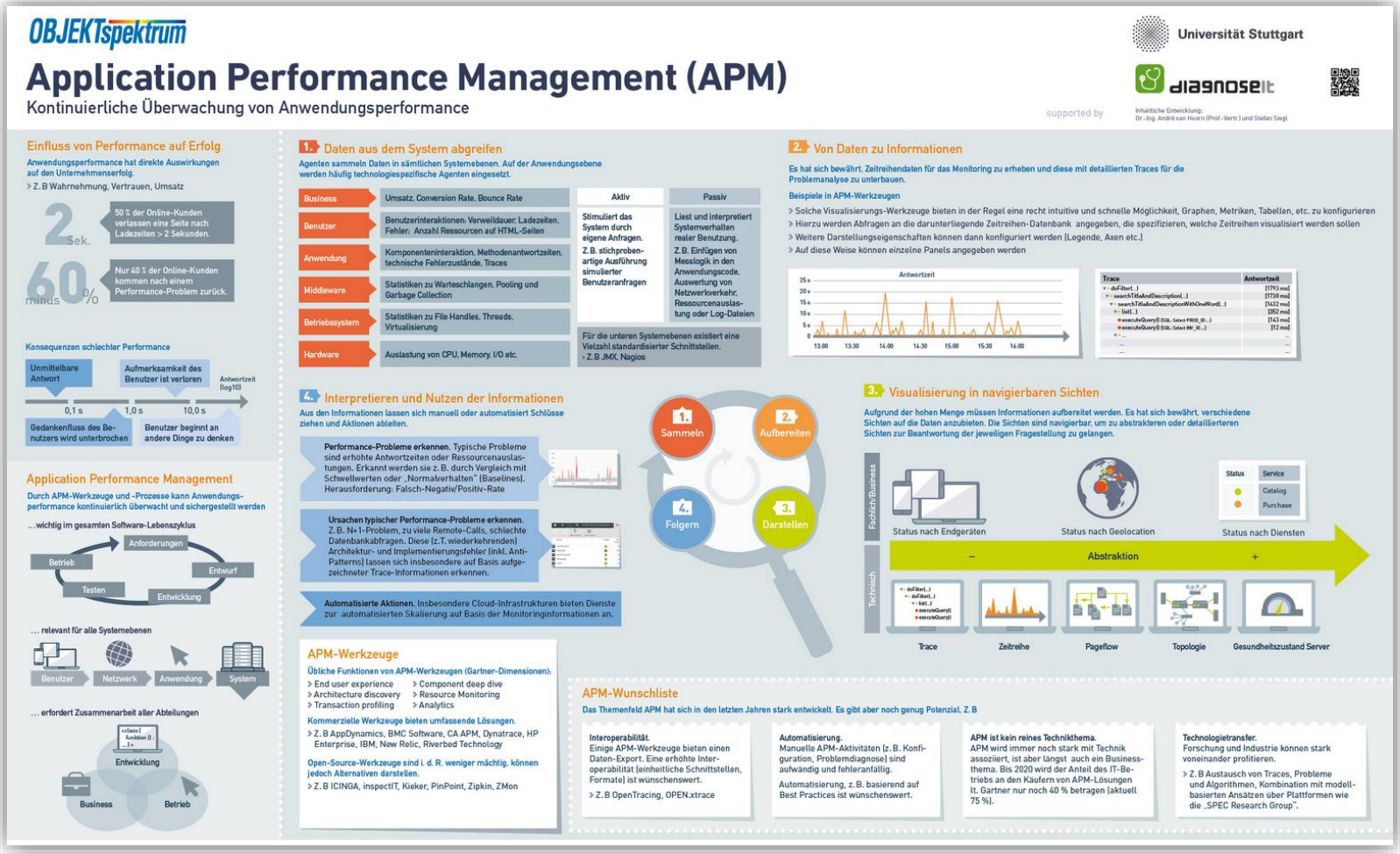
2.1 Data Collection

Various types of performance-relevant measures can and need to be collected from a system and its clients. A core decision of APM regarding data collection is *where*, *what*, and *how* to collect, as detailed in the remainder of this section and depicted in Figure 2.

2.1.1 Where to Collect Data?

Modern application systems are multi-tiered, highly distributed, and deployed, and accessed via different types of clients and devices (e.g., third-party systems and humans using desktop or mobile devices).

C. Heger, A. van Hoorn, D. Okanović, M. Mann:
Application performance management: State of the art and challenges for the future.
In: Proc. 8th ACM/SPEC ICPE, ACM (2017)



André van Hoorn und Stefan Siegl.
Application Performance Management (APM). Continuous Monitoring of Application Performance. (in German)
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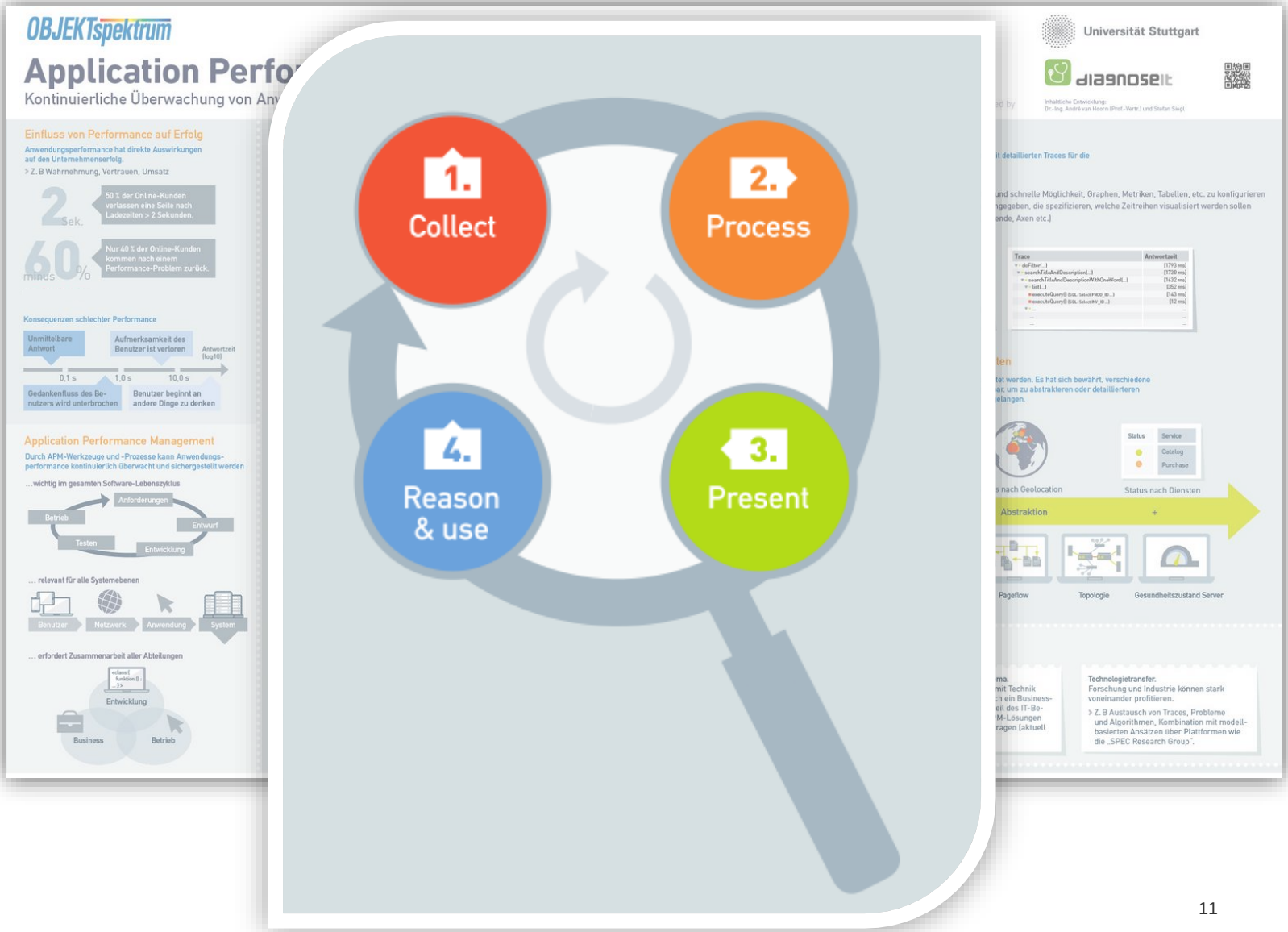
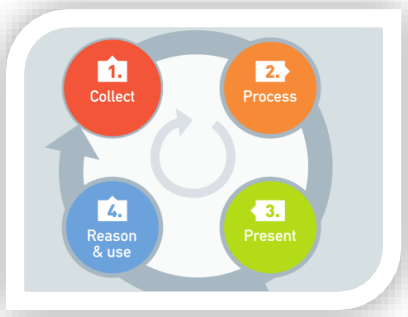

OBJEKTspektrum
Application Perfo
Kontinuierliche Überwachung von An
Einfluss von Performance auf Erfolg
Anwendungsperformance hat direkte Auswirkungen auf den Unternehmenserfolg.
> Z. B Wahrnehmung, Vertrauen, Umsatz
2 Sek.
50 % der Online-Kunden verlassen eine Seite nach Ladezeiten > 2 Sekunden.
60 %
Nur 40 % der Online-Kunden kommen nach einem Performance-Problem zurück.
Konsequenzen schlechter Performance
Unmittelbare Antwort
Aufmerksamkeit des Benutzer ist verloren
Antwortzeit (log10)
0,1 s
1,0 s
10,0 s
Gedankenfluss des Benutzers wird unterbrochen
Benutzer beginnt an andere Dinge zu denken
Application Performance Management
Durch APM-Werkzeuge und -Prozesse kann Anwendungsperformance kontinuierlich überwacht und sichergestellt werden
...wichtig im gesamten Software-Lebenszyklus
Anforderungen
Entwurf
Entwicklung
Testen
Betrieb
... relevant für alle Systemebenen
Benutzer
Netzwerk
Anwendung
System
... erfordert Zusammenarbeit aller Abteilungen
Entwicklung
Business
Betrieb
1.
Collect
2.
Process
3.
Present
4.
Reason & use
Universität Stuttgart
diagnoseIT
Inhaltliche Entwicklung:
Dr.-Ing. André van Hoorn (Prof.-Vertr.) und Stefan Siegl
detaillierten Traces für die
und schnelle Möglichkeit, Graphen, Metriken, Tabellen, etc. zu konfigurieren
angegeben, die spezifizieren, welche Zeitreihen visualisiert werden sollen
onde, Axen etc.)
Trace
Antwortzeit
doFilter(...)
searchTitleAndDescription(...)
searchTitleAndDescriptionWithOneWord(...)
list(...)
executeQuery() [SQL: Select FROM_ID...]
executeQuery() [SQL: Select INV_ID...]
[1793 ms]
[1730 ms]
[1632 ms]
[852 ms]
[143 ms]
[12 ms]
ten
tet werden. Es hat sich bewährt, verschiedene
ar, um zu abstrakteren oder detaillierteren
elangen.
Status
Service
Catalog
Purchase
s nach Geolocation
Status nach Diensten
Abstraktion
+
Pageflow
Topologie
Gesundheitszustand Server
Technologietransfer.
Forschung und Industrie können stark voneinander profitieren.
> Z. B Austausch von Traces, Probleme und Algorithmen, Kombination mit modellbasierten Ansätzen über Plattformen wie die „SPEC Research Group".

1. Collecting Data from All System Levels



- Agents collect data from all system levels
- On application level the agents are often technology-dependent

Where?	What?
Business	Sales data, conversion and bounce rate
User	User interactions: length of stay, load times, errors; number of resources on HTML pages
Application	Component interactions, method response times, trace data
Middleware	Queuing statistics, pooling, garbage collection
Operating System	File handling statistics, virtualization, thread statistics
Hardware	CPU load, memory consumption, I/O statistics

How?

Active	Passive
Stimulation of the system by periodic requests. E.g., synthetic user transactions	Collection of runtime data from real system usage. E.g., injection of code, analysis of network traffic, resource utilization, or log files

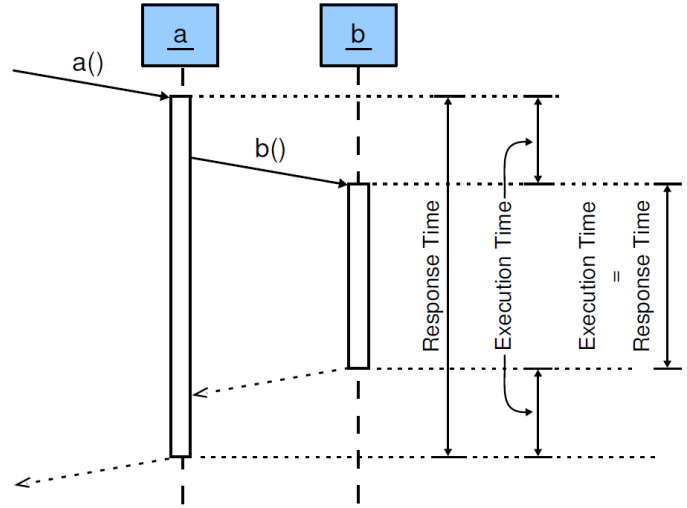
Some technologies on lower levels provide standard interfaces for data collection, e.g., Nagios, JMX

Trace-based Metrics (Selection)

What?

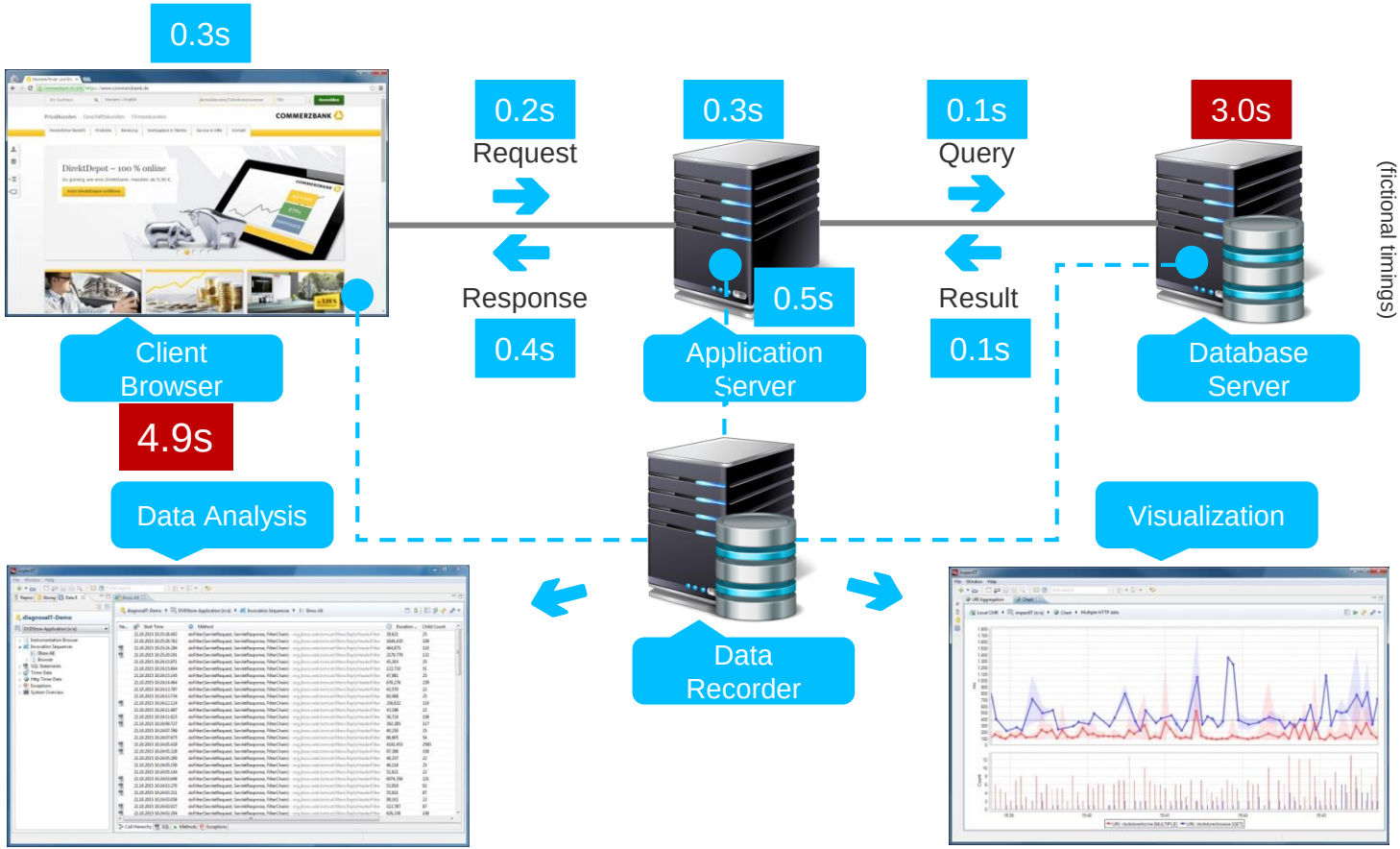
Application	Component interactions, method response times, trace data

Metric
Response Time
CPU Time
Method Name
Return Type
Logging Level
SQL Statement
Error Message
…

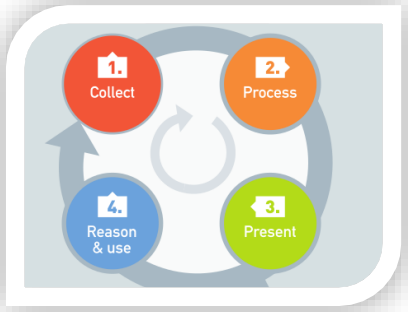


Okanović, D., van Hoorn, A., Heger, C., Wert, A., Siegl, S.:
Towards performance tooling interoperability: An open format for representing execution traces.
In: Proc. EPEW ’16. LNCS, Springer (2016)

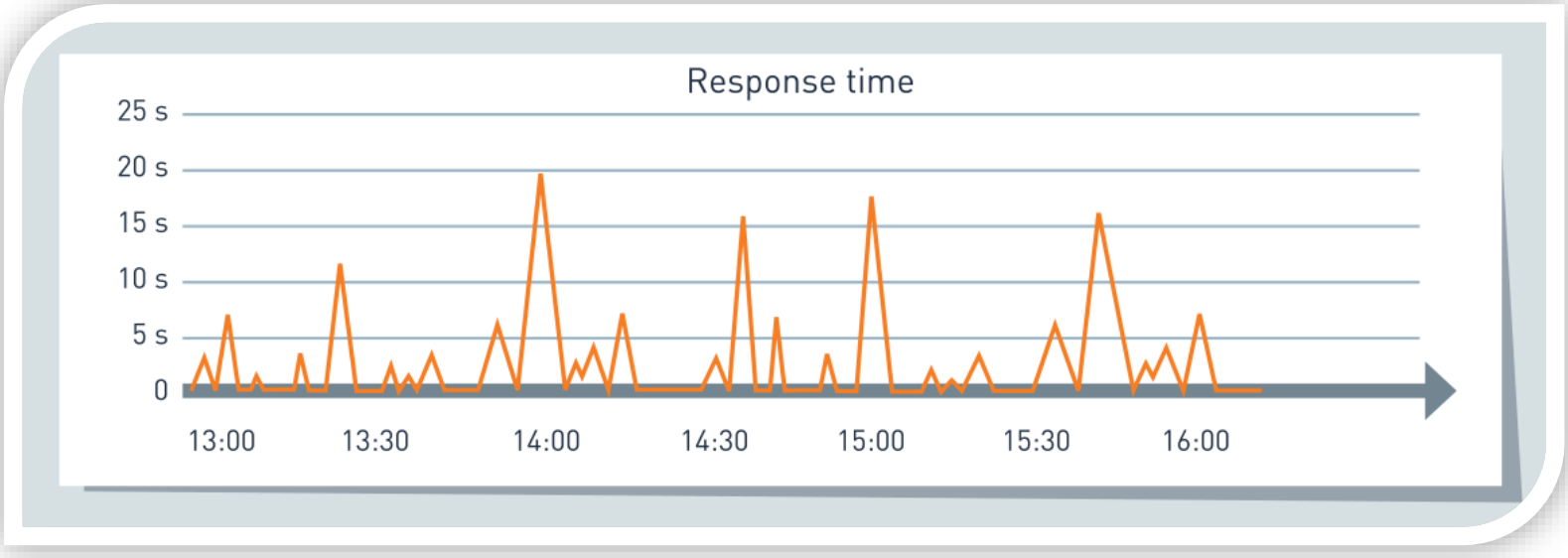
Monitoring (Measurement-based Performance Evaluation)



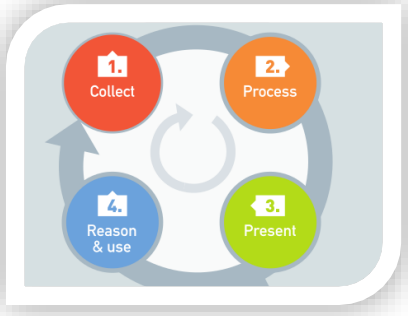
2. Reconstructing Information from Data



- Data is collected from the system…
- represented as **time series**…



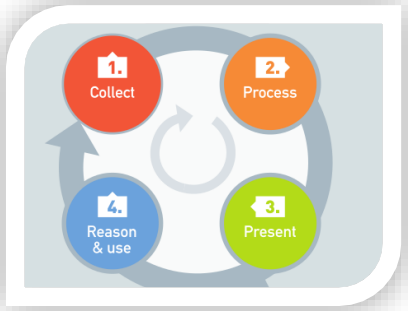
2. Reconstructing Information from Data



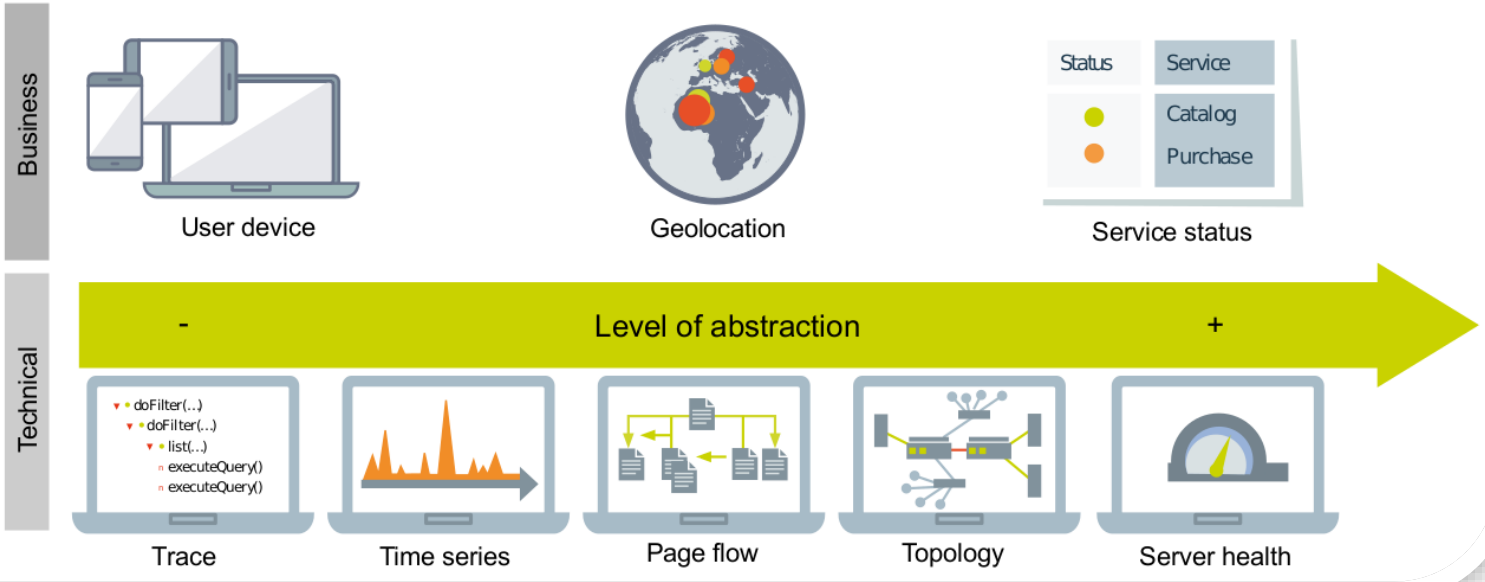
- Data is collected from the system…
- represented as **time series**…
- … and as **detailed execution traces**, and used to support problem analysis

Trace	Response time
▼ ● doFilter(...)	[1793 ms]
▼ ● searchTitleAndDescription(...)	[1730 ms]
▼ ● searchTitleAndDescriptionWithOneWord(...)	[1632 ms]
▼ ● list(...)	[352 ms]
■ executeQuery() {SQL: Select PROD_ID ...}	[143 ms]
■ executeQuery() {SQL: Select INV_ID ...}	[12 ms]
▼ ● ...	...
... ...	
...	...

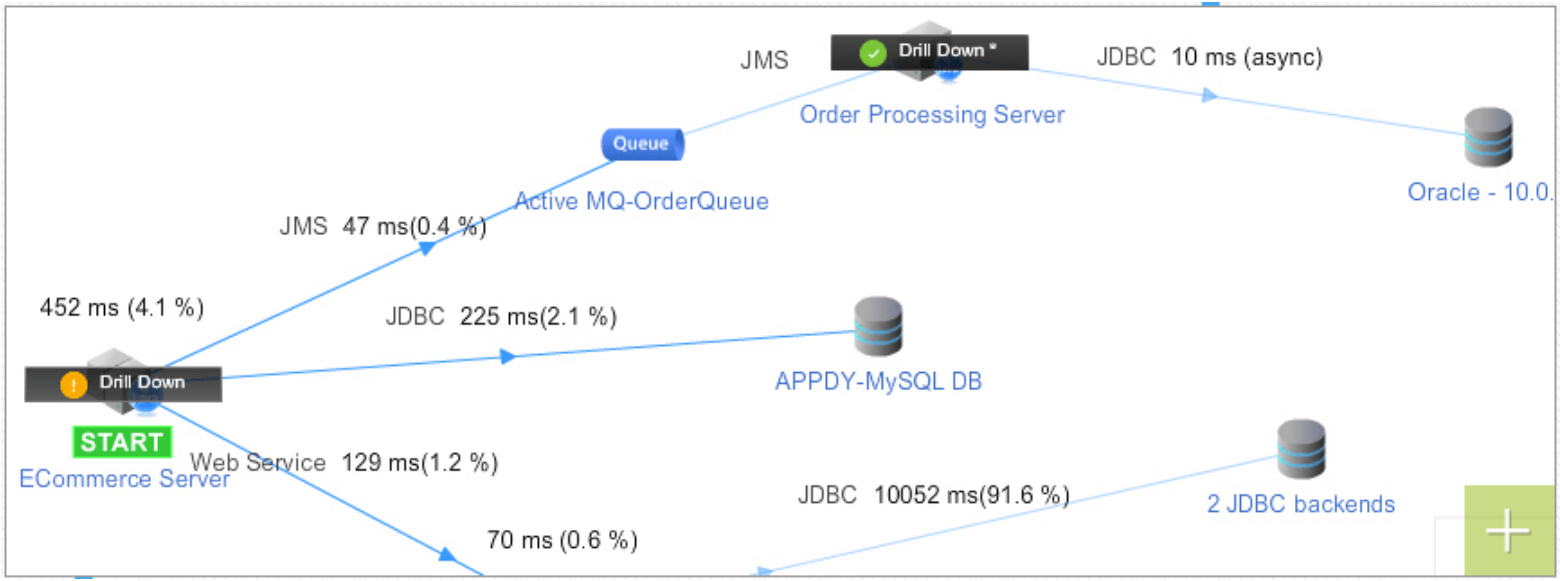
3. Visualization Through Navigable Views



- High quantity of information has to be pre-processed
- It has proven useful to use **different views** to show the data
- **Views are navigable** and can be categorized by both scope and detail level

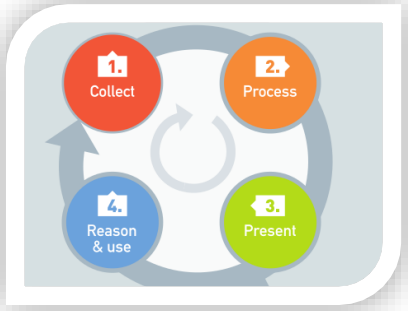


Example: Application Topology Discovery and Visualization



© AppDynamics

4. Interpreting and Using the Information



Manual or automated conclusions and actions can be derived from the information, e.g.,

- **Problem detection and alerting**
  - E.g., increased response times and resource utilization
  - Detection, for instance, based on thresholds and baselines
- **Problem diagnosis and root cause isolation**
  - E.g., N+1 problem, too many remote calls, poor DB queries
  - Detection based on monitoring information
- **System refactoring and adaptation**
  - E.g., auto-scaling in cloud-based architectures

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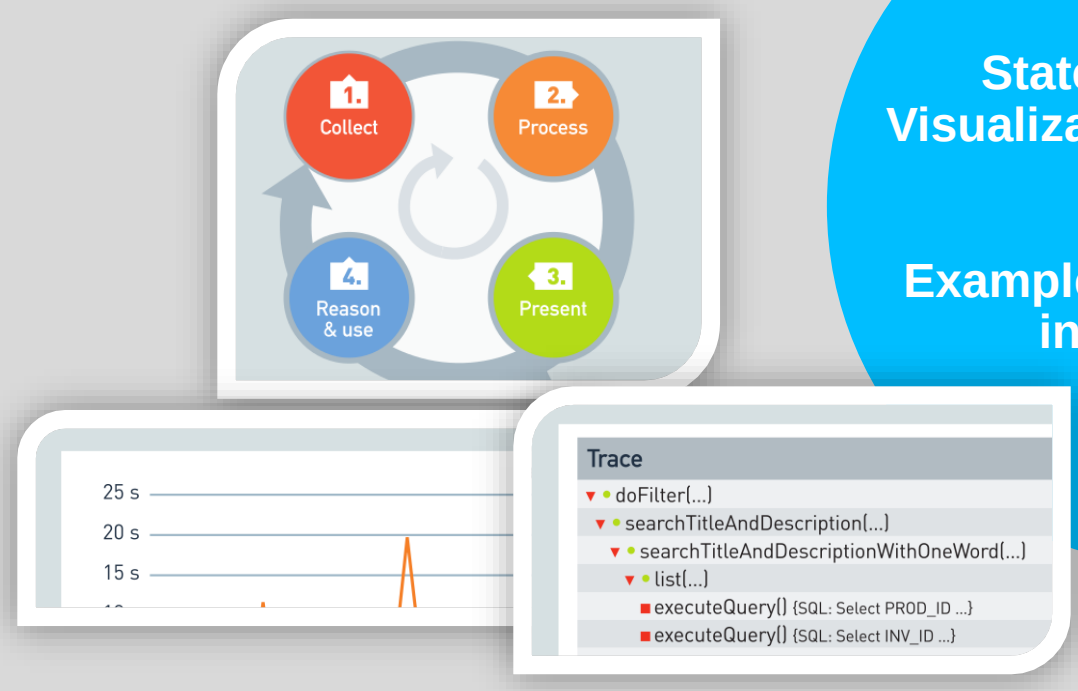

State of the Art of Visualization in APM Tools

Part 2/2: Examples Visualizations in APM Tools

André van Hoorn
Dušan Okanović

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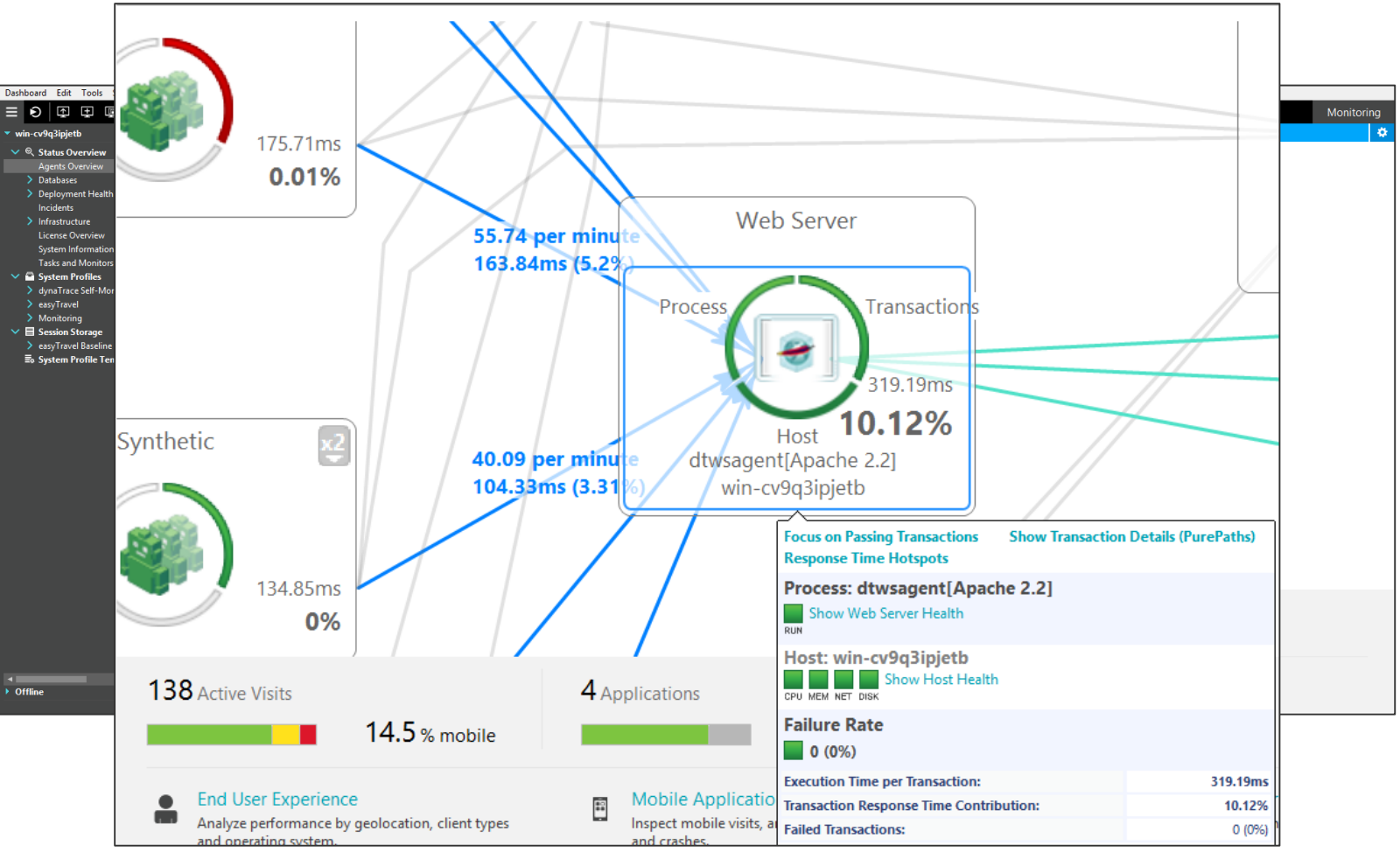
Commercial APM Tools

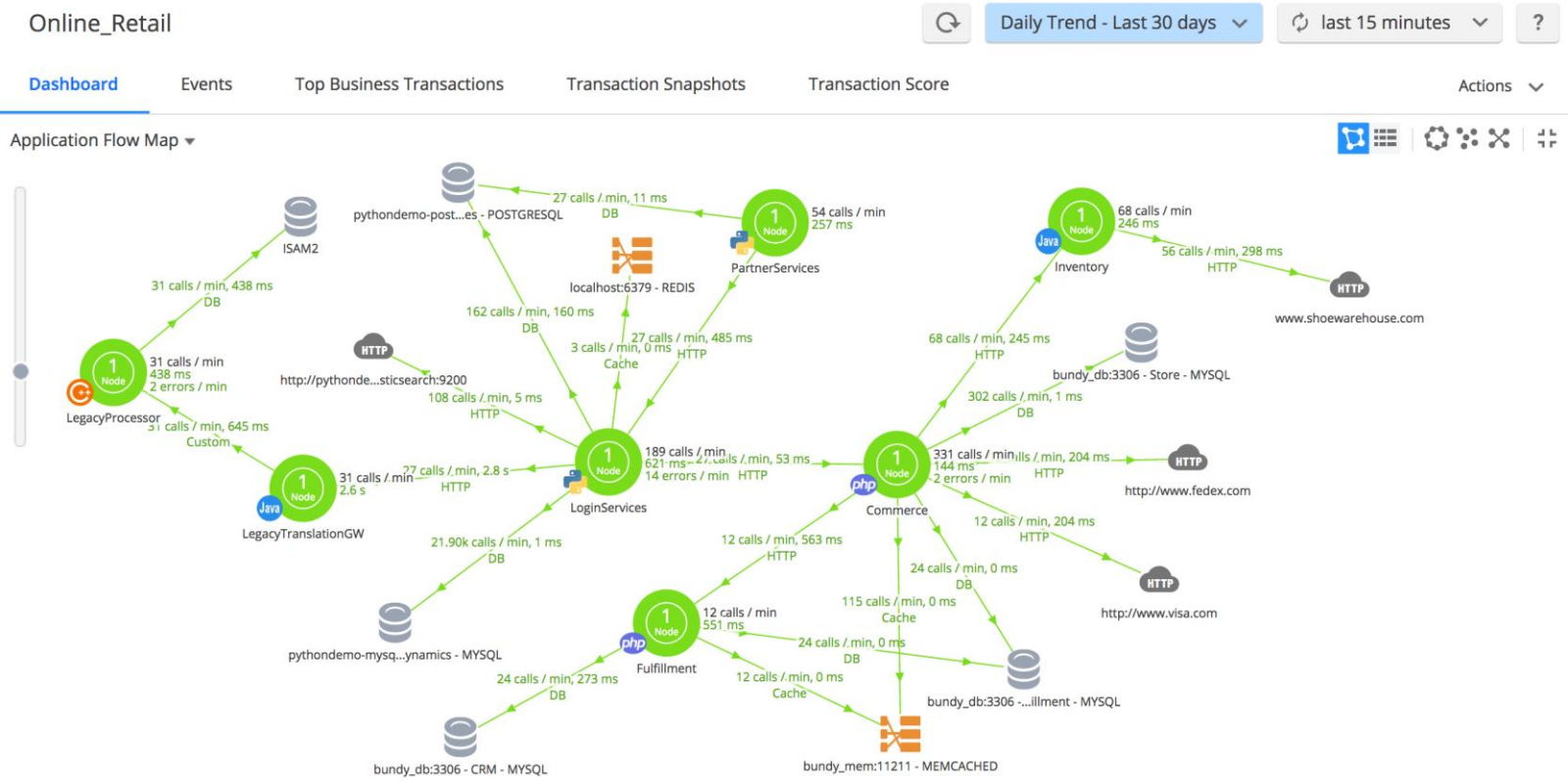
Magic Quadrant

Source: Gartner (March 2018)

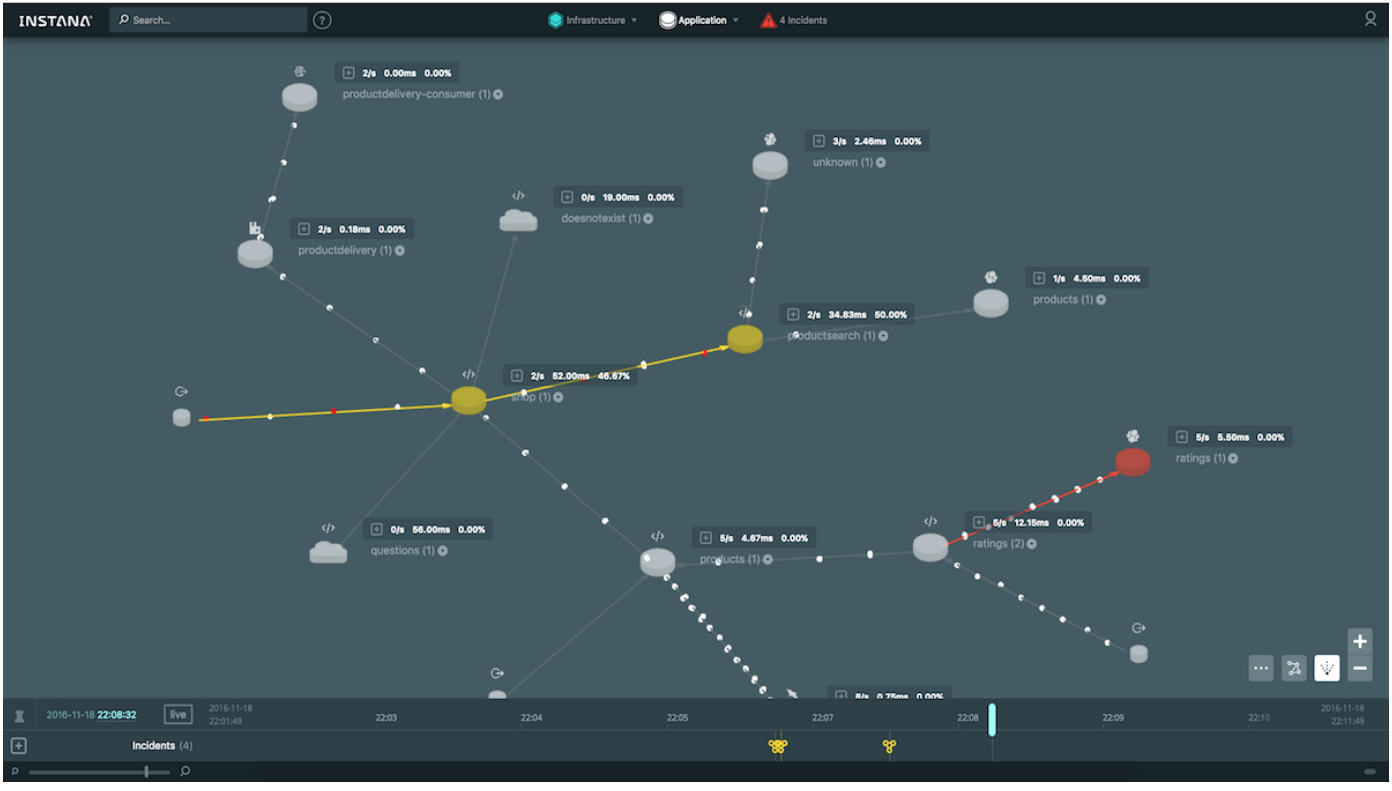
Application Overview – Dynatrace



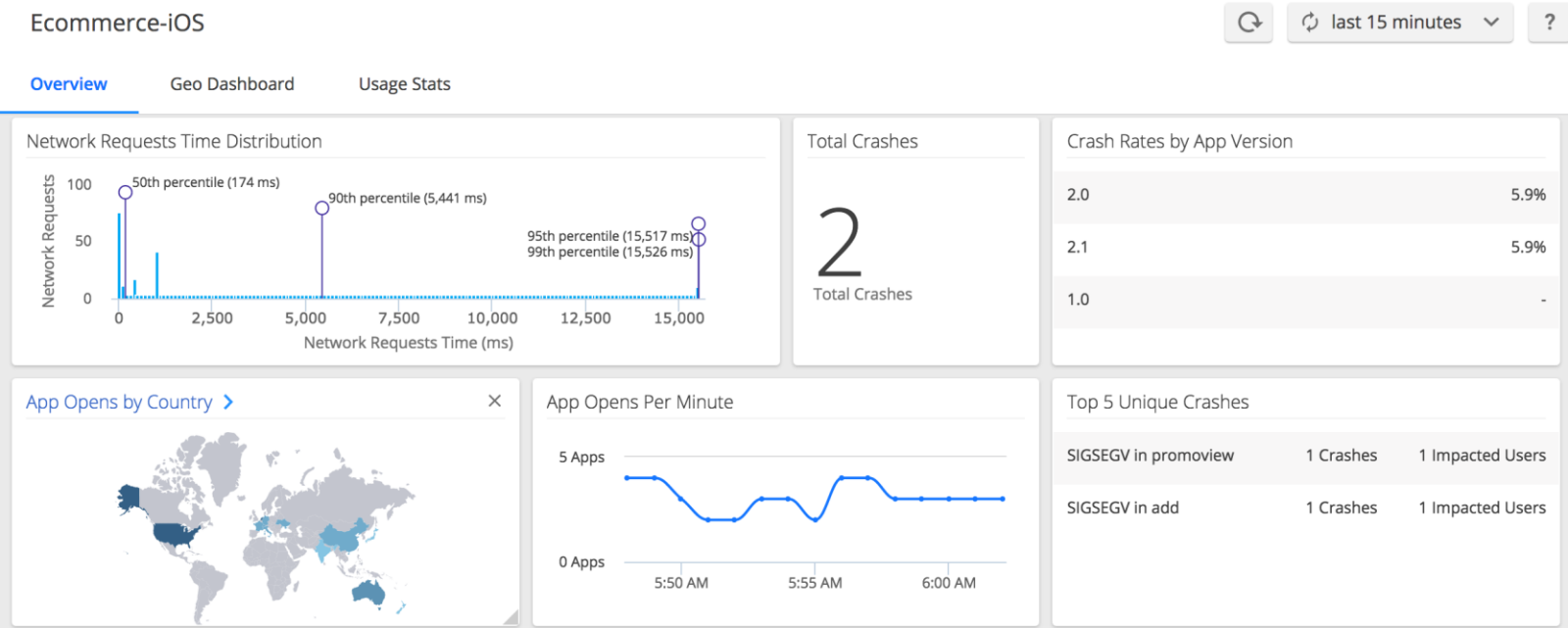
Application Overview – AppDynamics



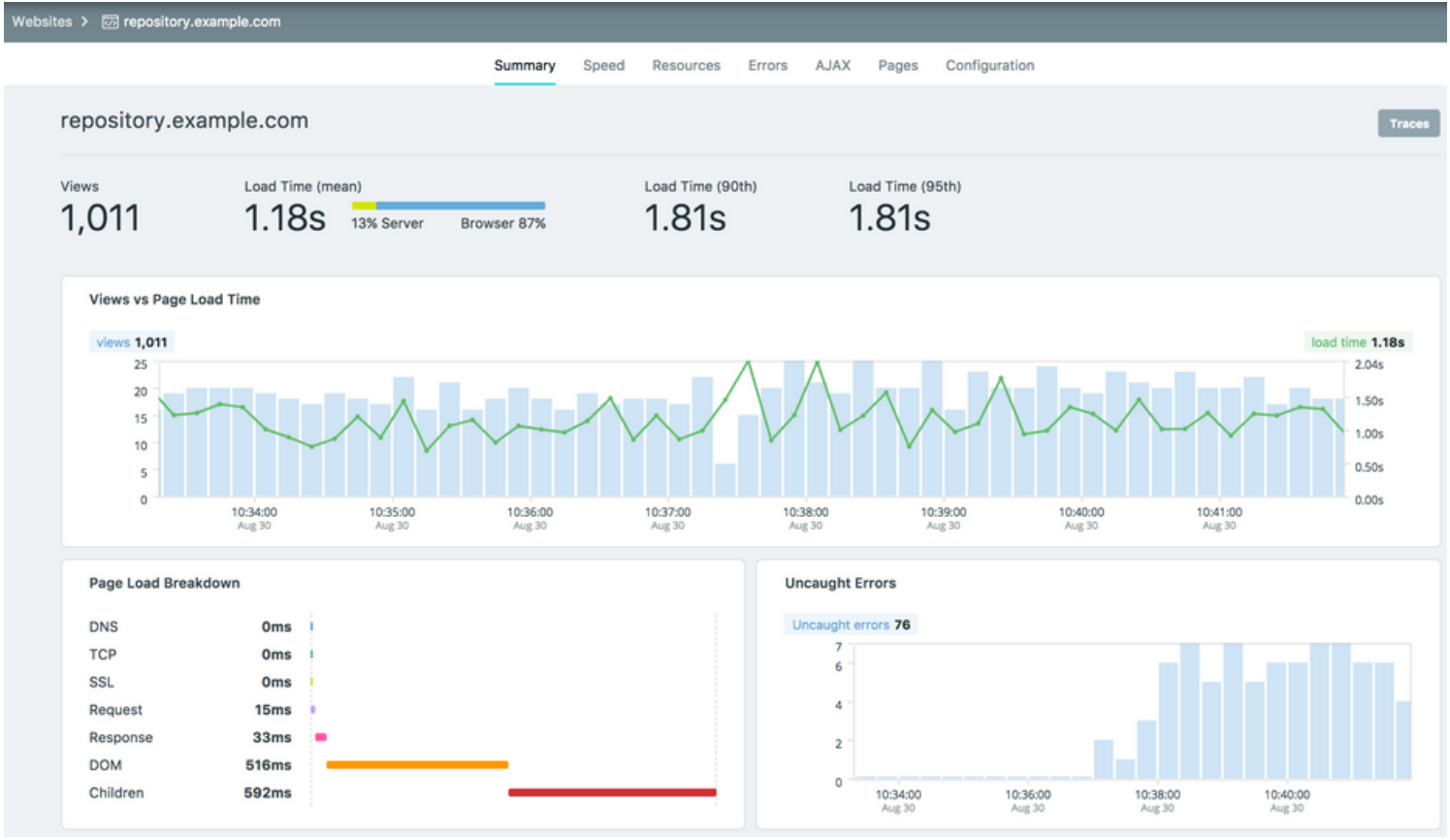
Application Overview – Instana



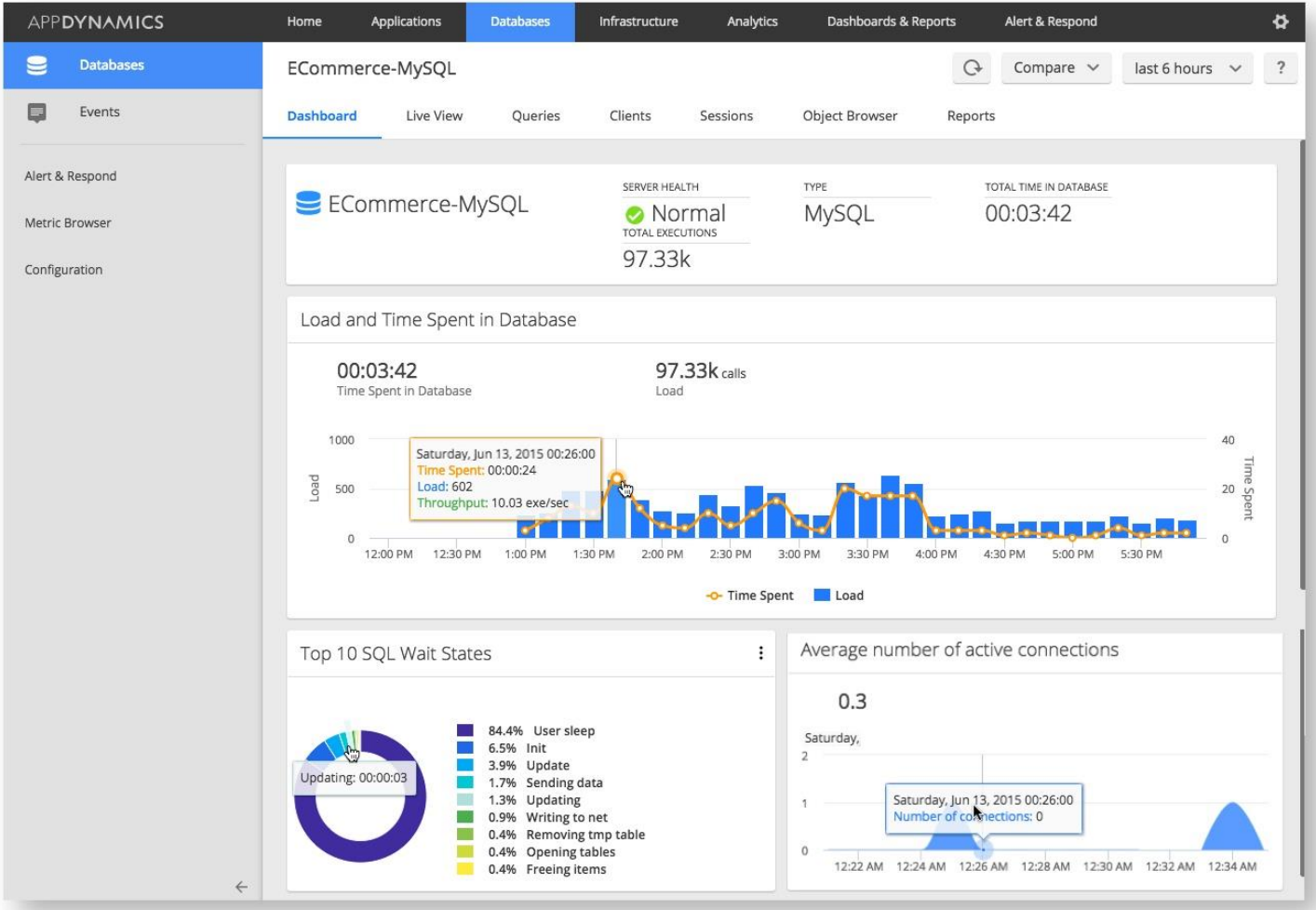
End User Monitoring – AppDynamics



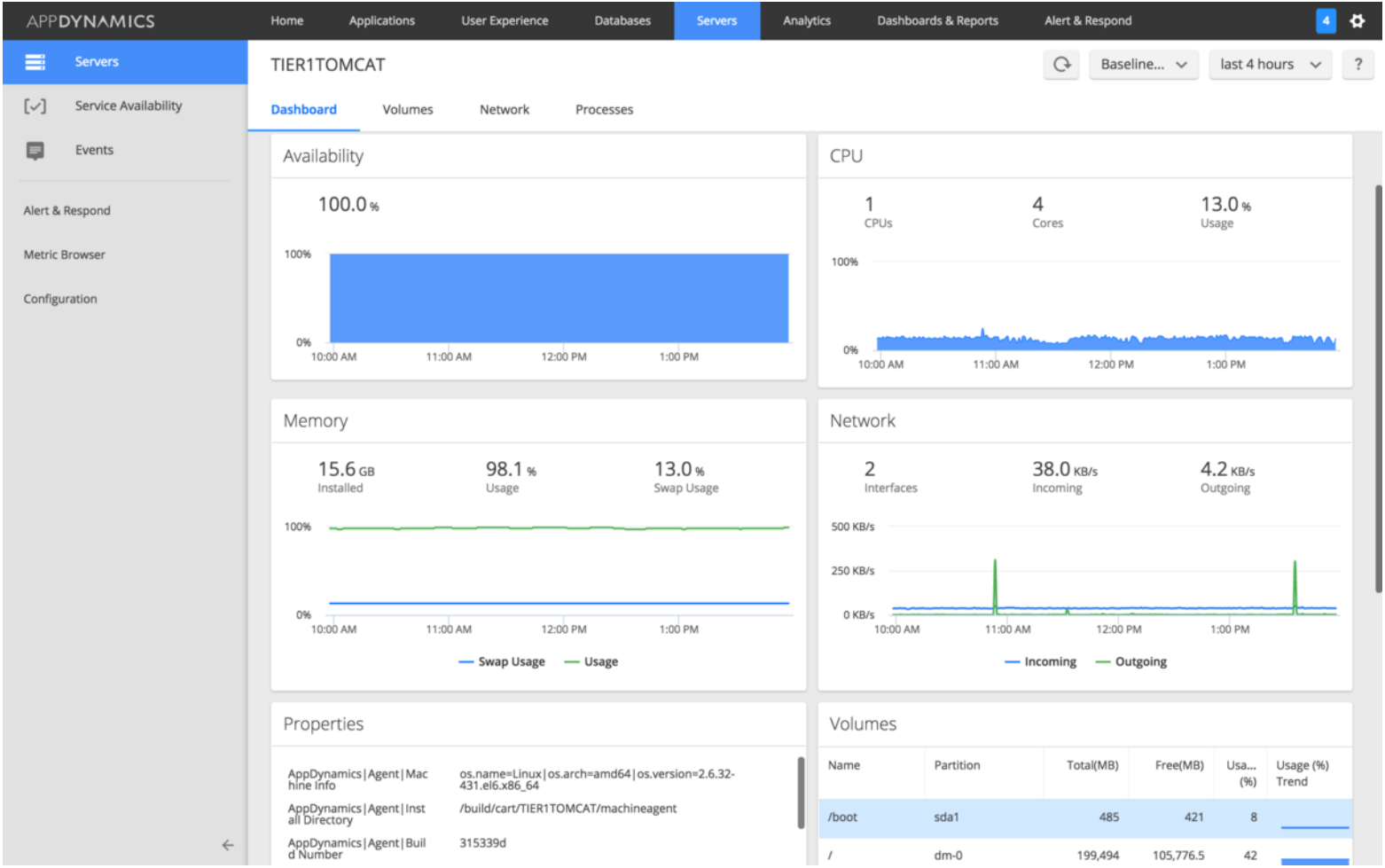
End User Monitoring– Instana



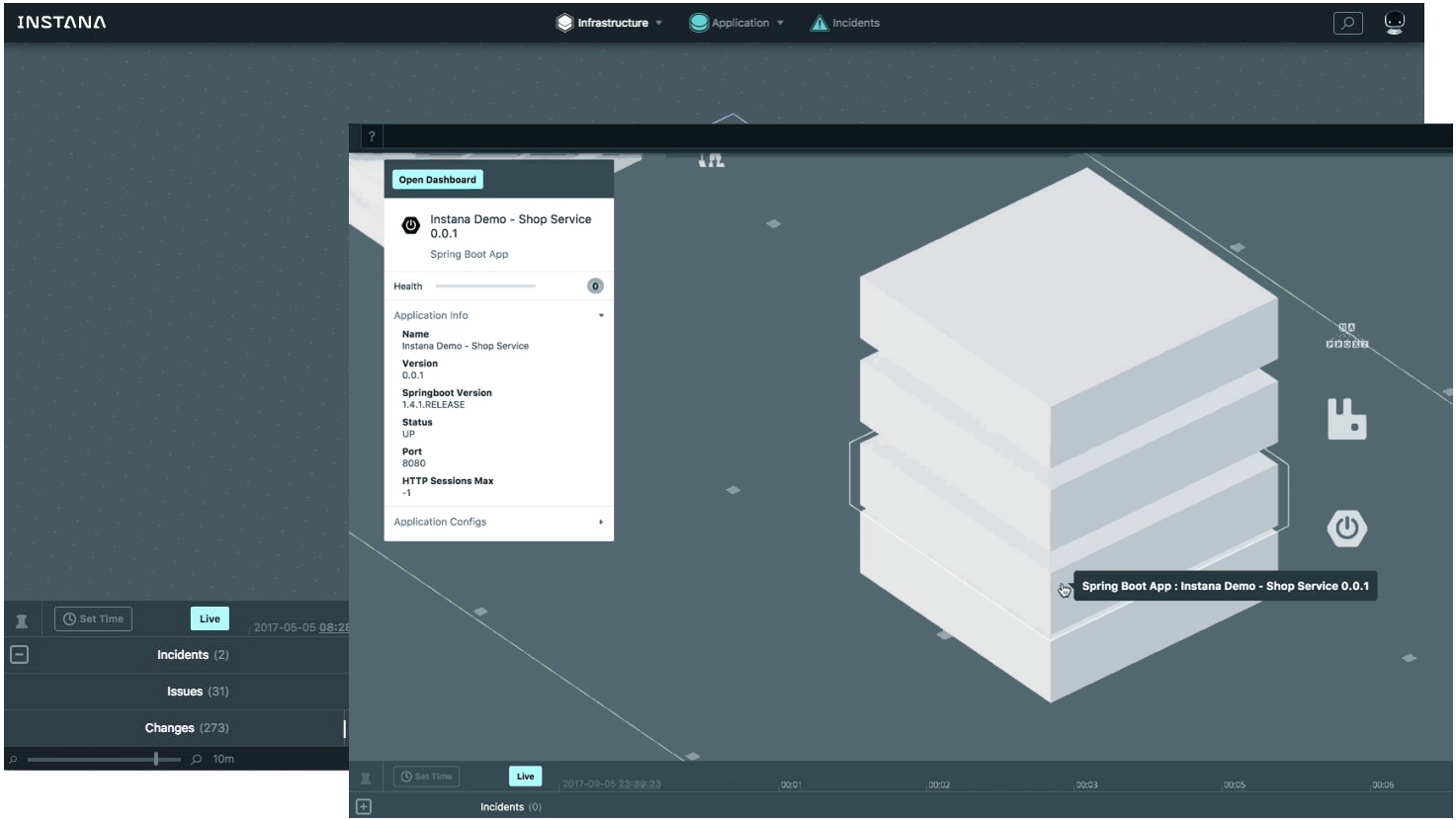
Database Monitoring – AppDynamics



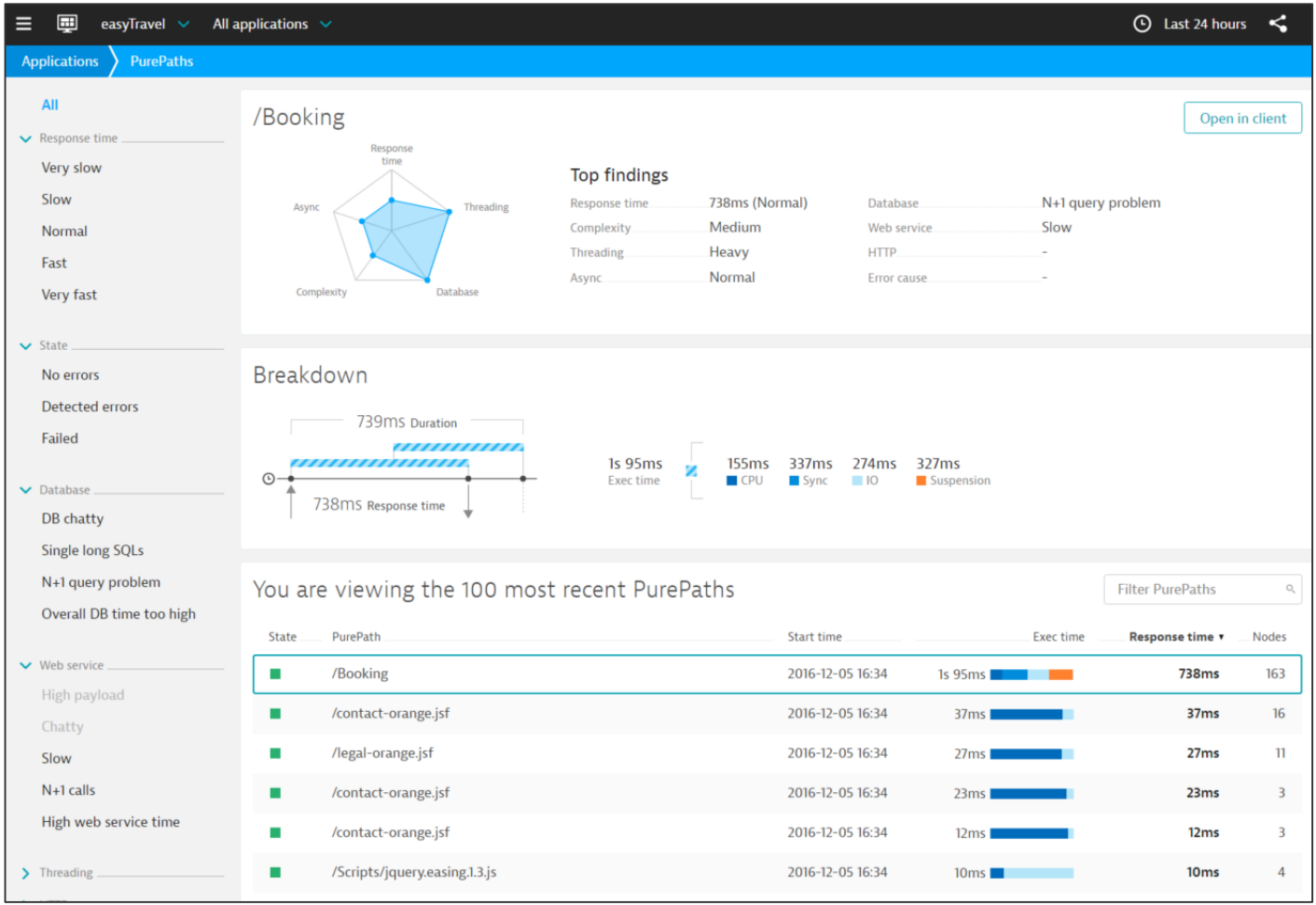
Server Monitoring – AppDynamics



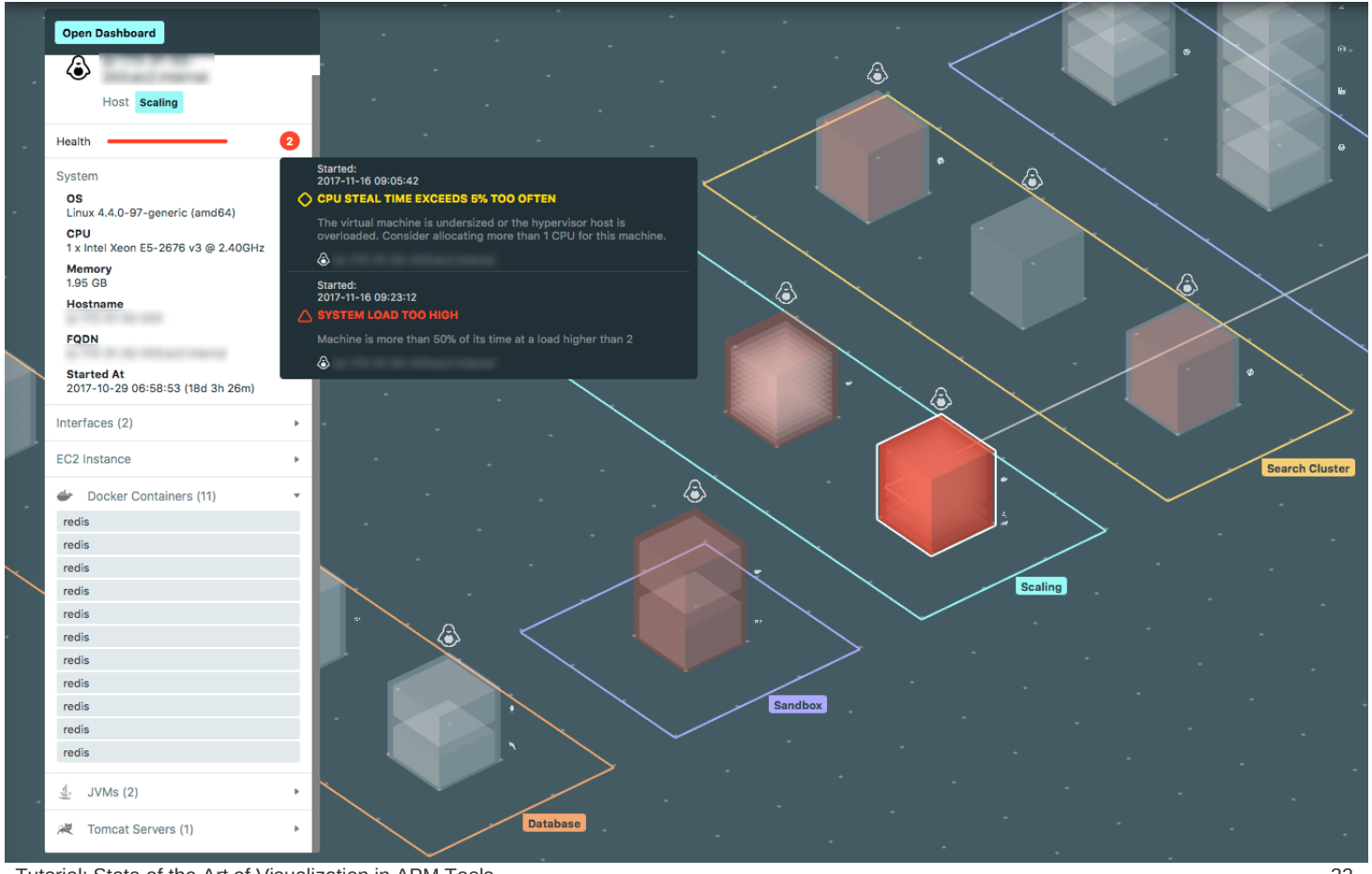
Server Monitoring – Instana



Problem Identification – Dynatrace

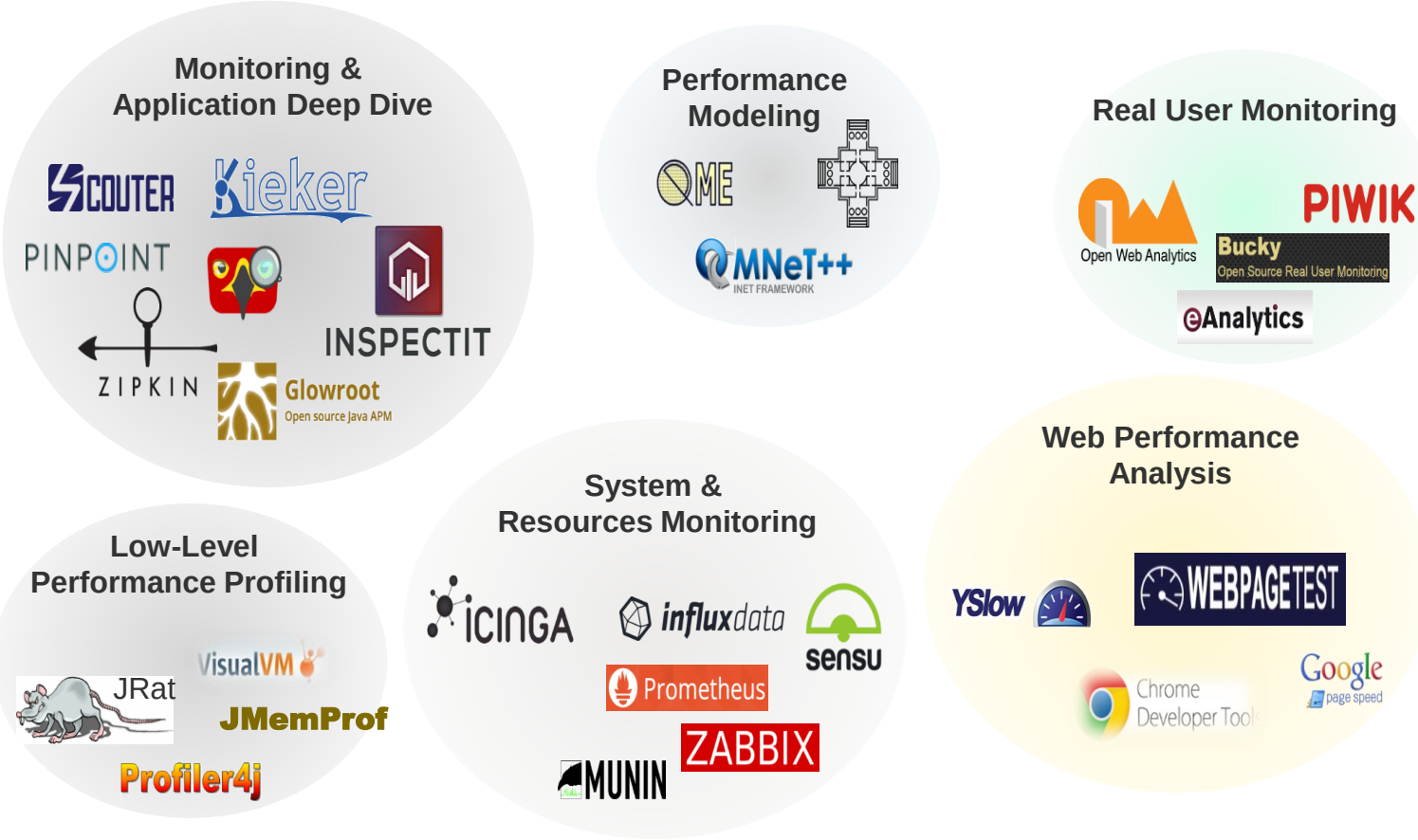


Problem Identification - Instana

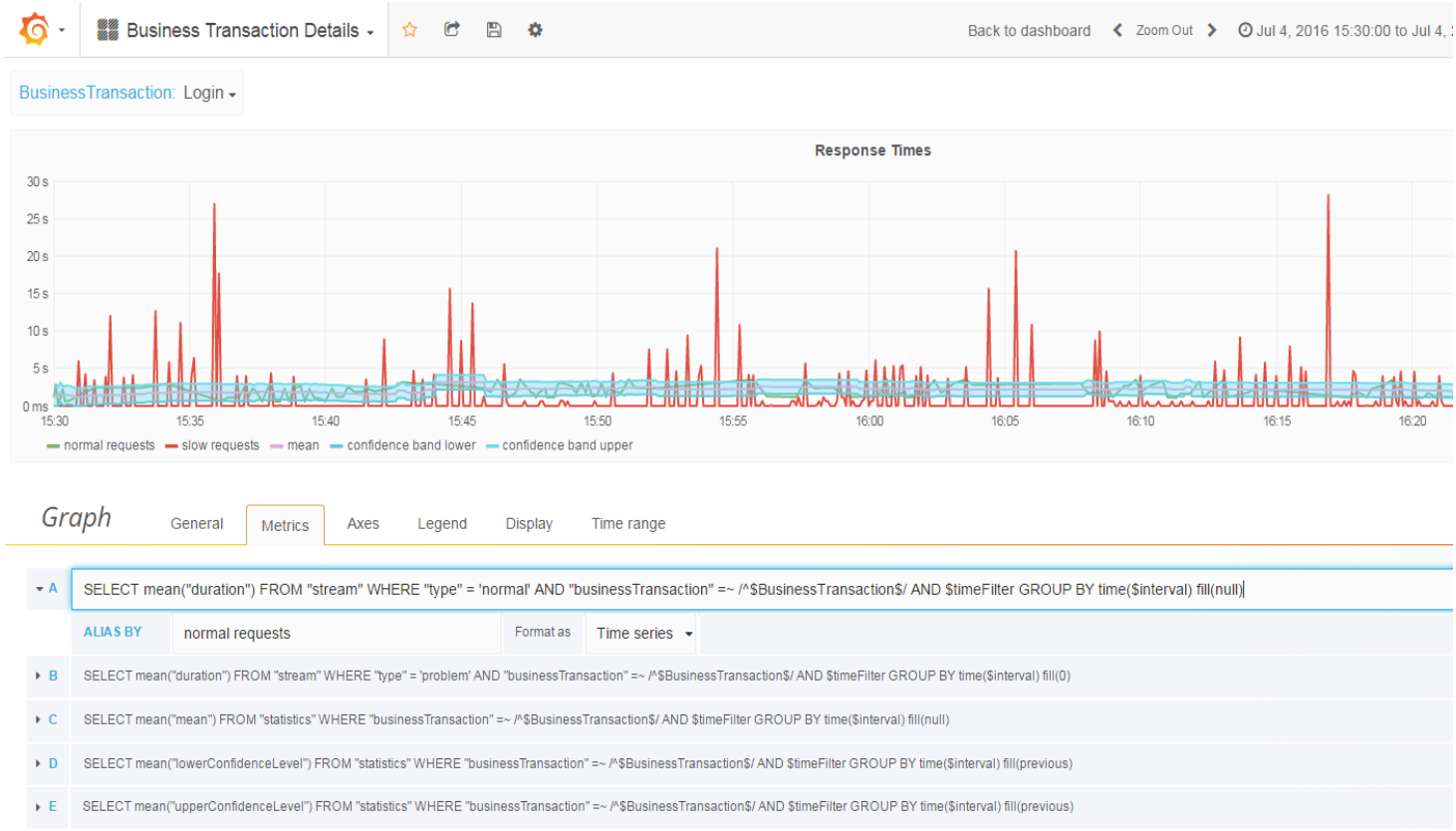


Open Source APM tools

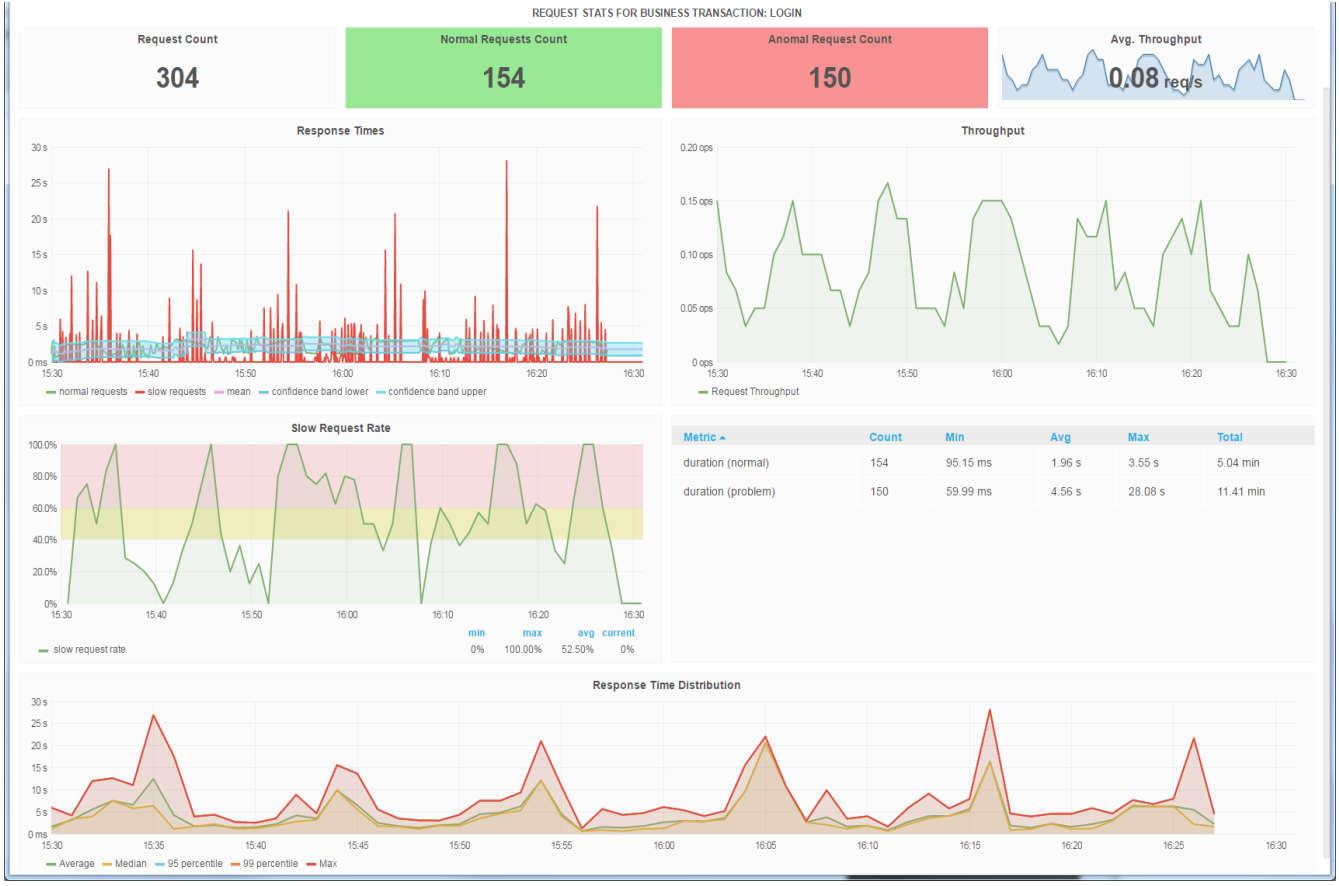
Open Source APM tools



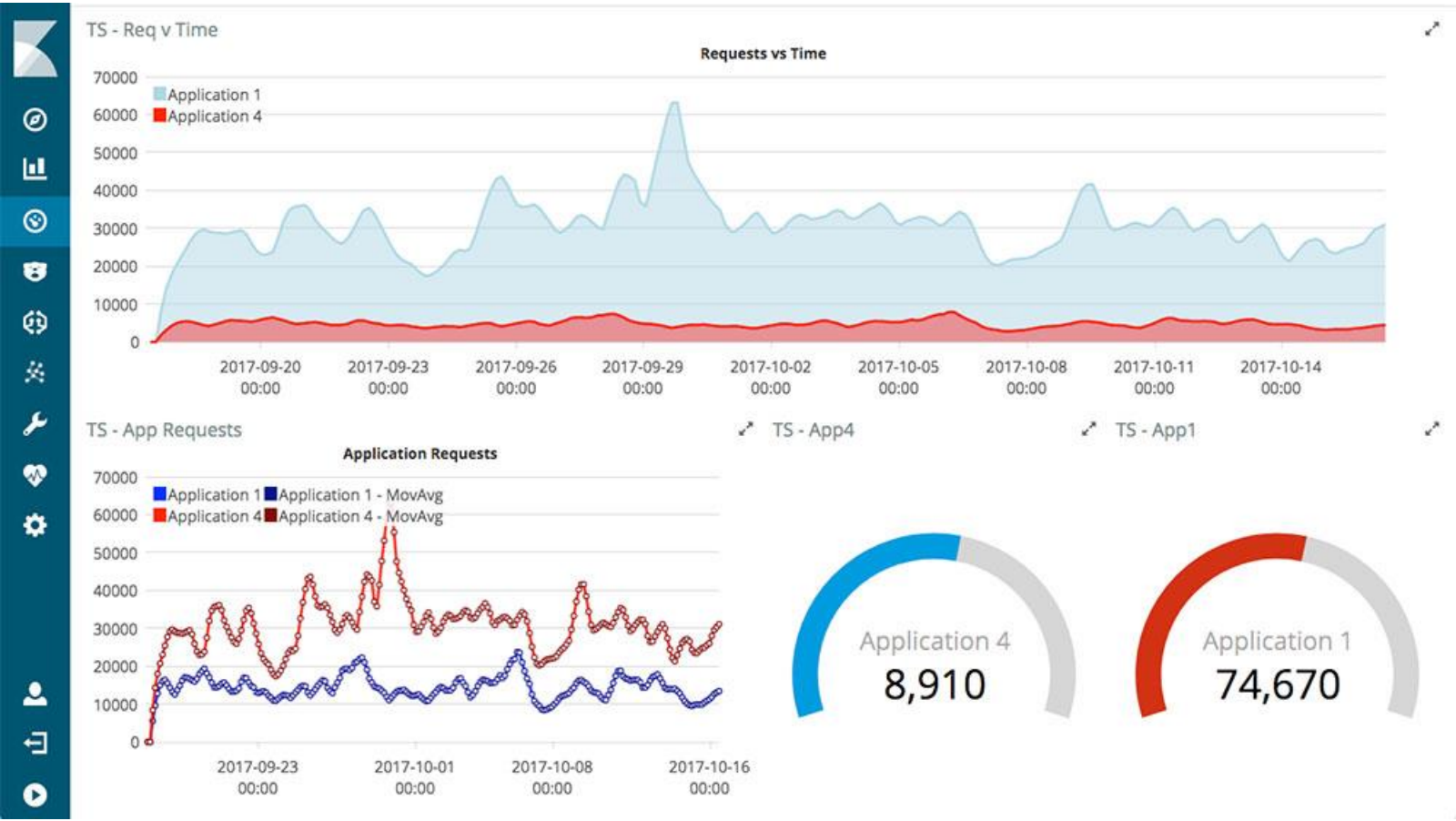
Dashboards – Grafana



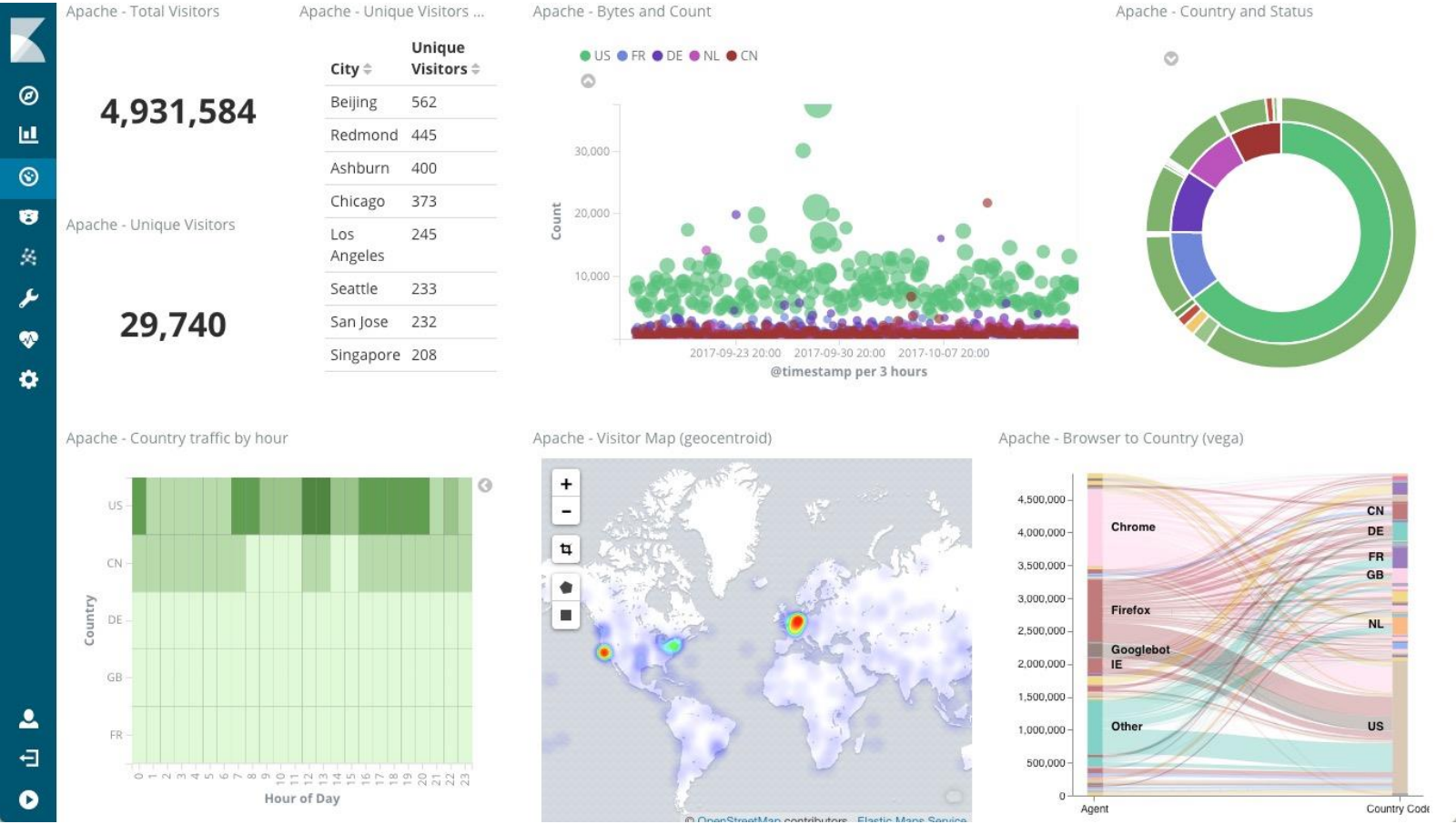
Dashboards – Grafana



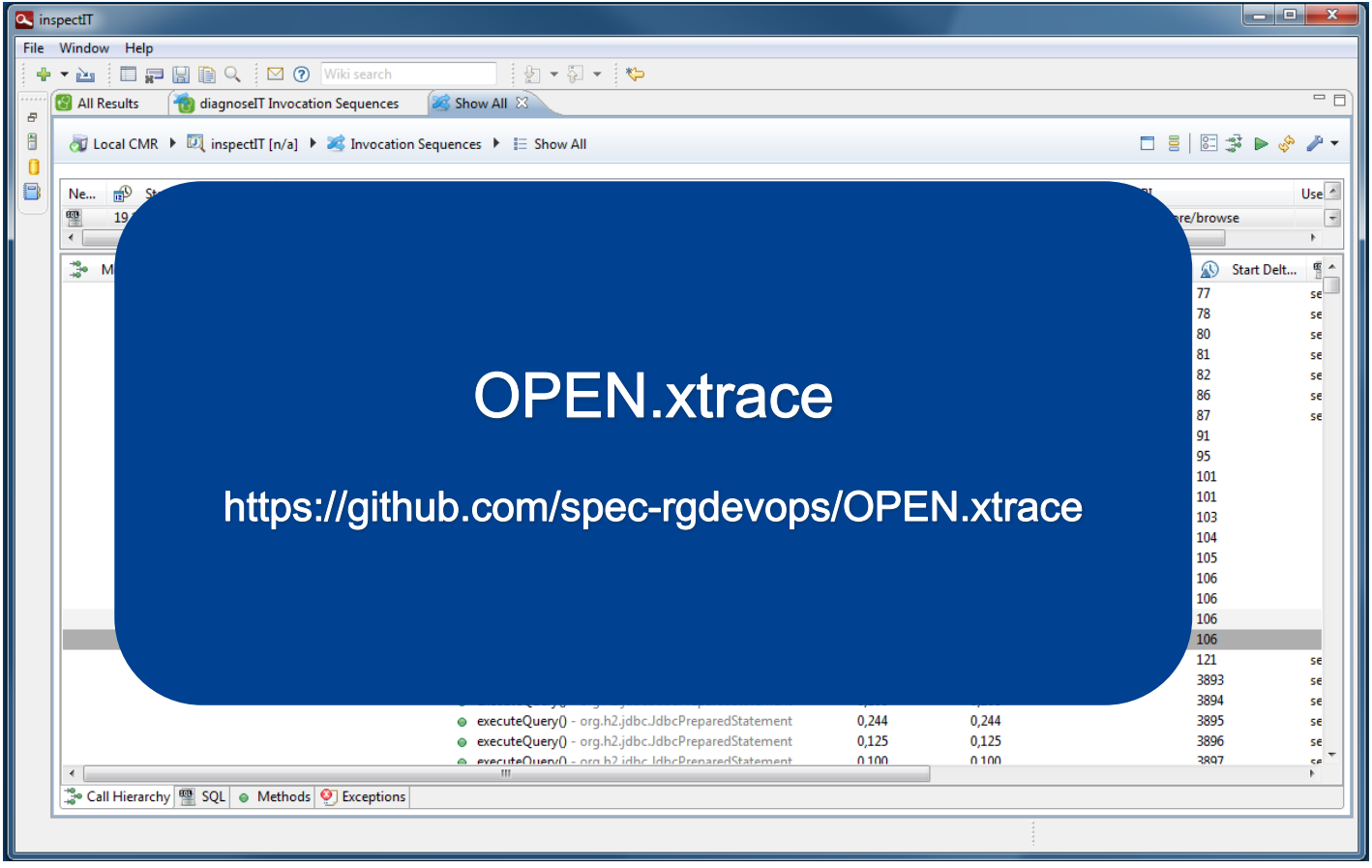
Dashboards – Kibana



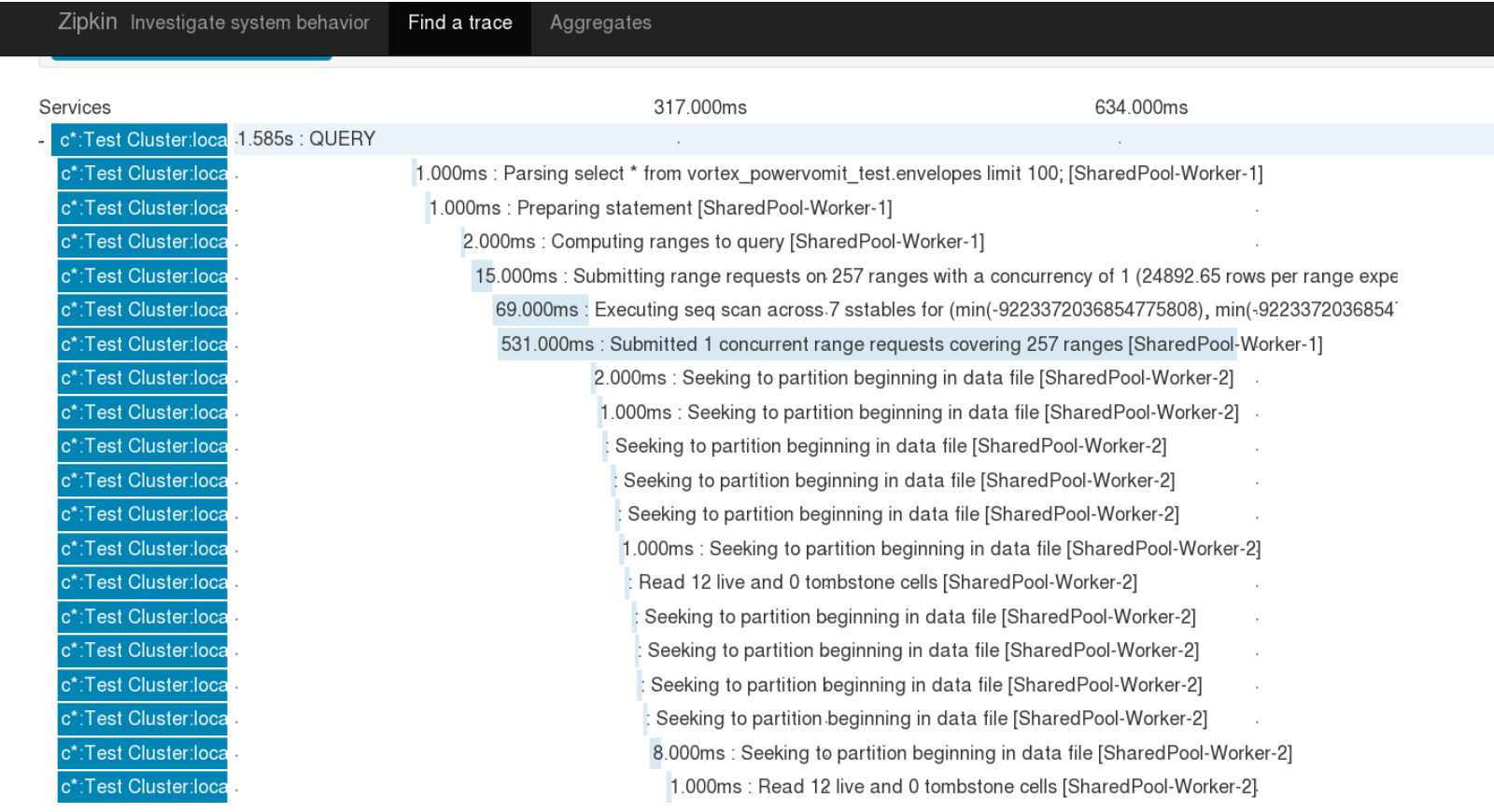
Dashboards – Kibana



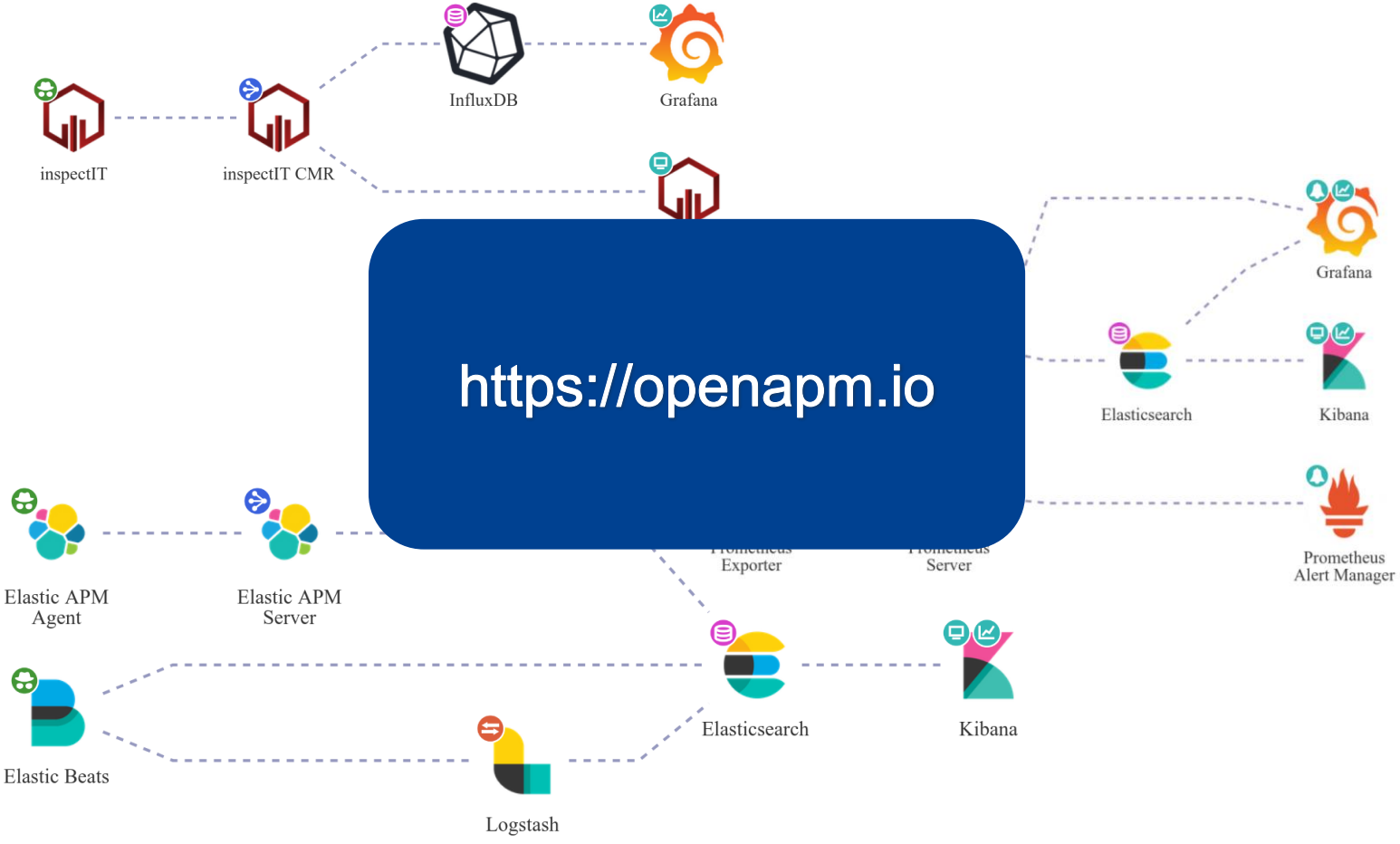
Execution Traces – inspectIT



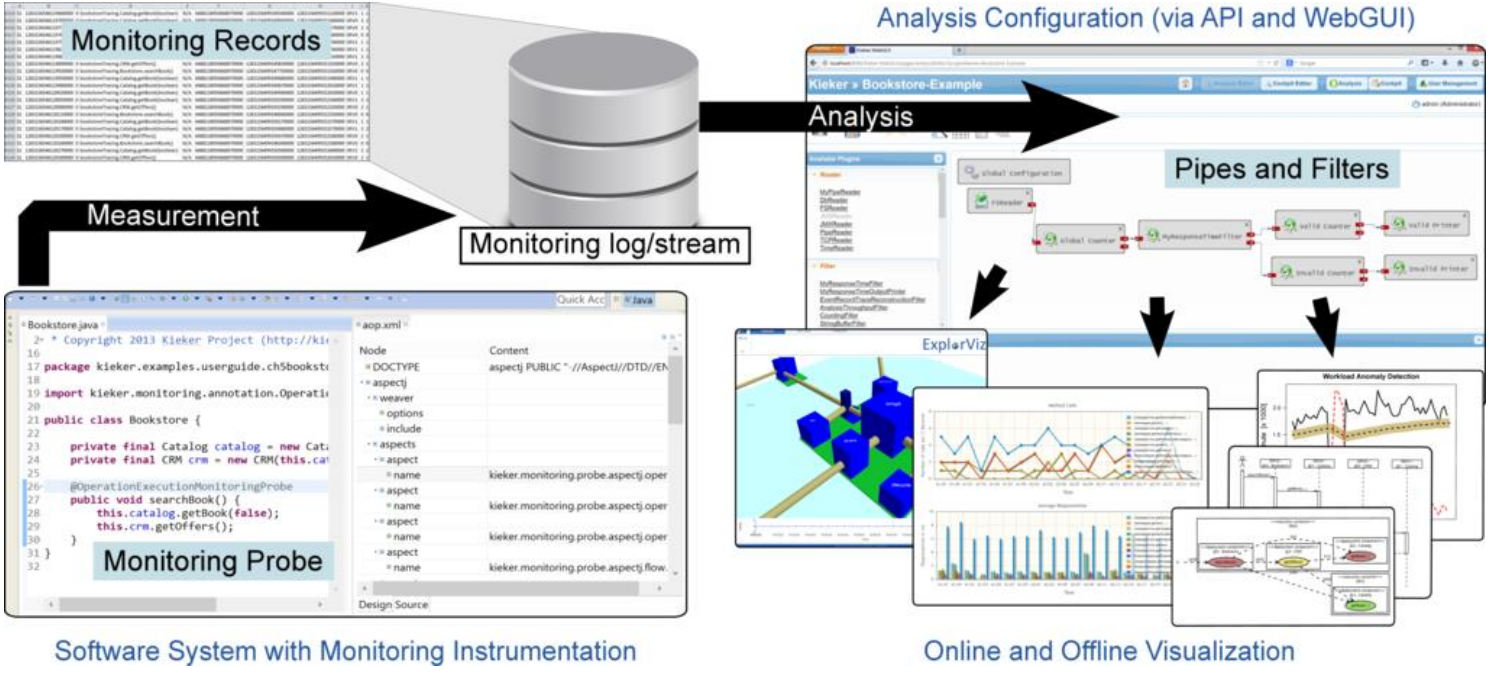
Tracing – Zipkin



Build Your Own Landscape



Dynamic Software Analysis and Application Performance Management

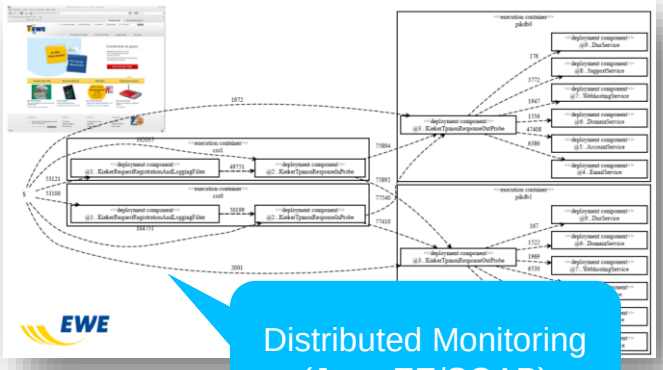


- http://kieker-monitoring.net

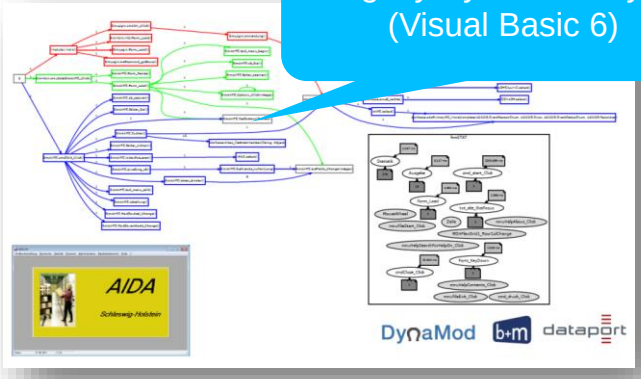
Kieker is distributed as part of SPEC® RG's repository of peer-reviewed tools for quantitative system evaluation and analysis

http://research.spec.org/projects/tools.html

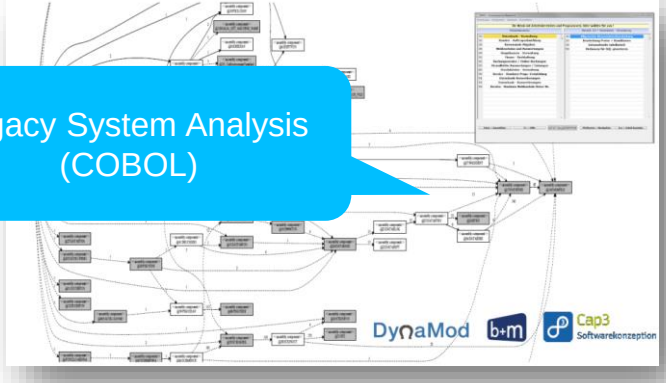
Application (and Visualization) Examples



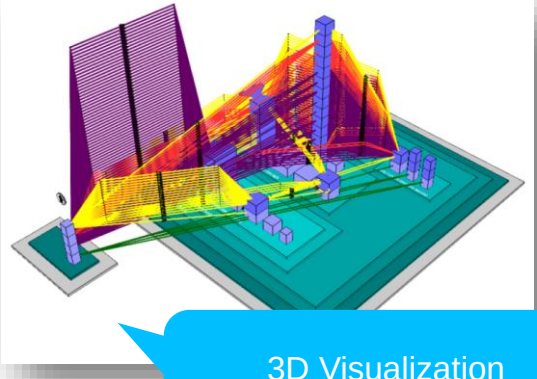
Distributed Monitoring
(Java EE/SOAP)



Legacy System Analysis
(Visual Basic 6)



Legacy System Analysis
(COBOL)



3D Visualization
of Concurrency

Conclusion

- Commercial tools have most fancy visulizations

  … how useful are they really?

- Open-source tools are flexible and can be adapted as needed

  … but require a lot of work to setup

- Thanks to a more widespread adoption of (open-source) APM, it is easier to get access to rich APM data (e.g., distributed traces) and to integrate visualization approaches (e.g., via APIs)

  … if you know what and how to visualize