TraViz: Visualization of Distributed Traces

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What are Distributed Systems?

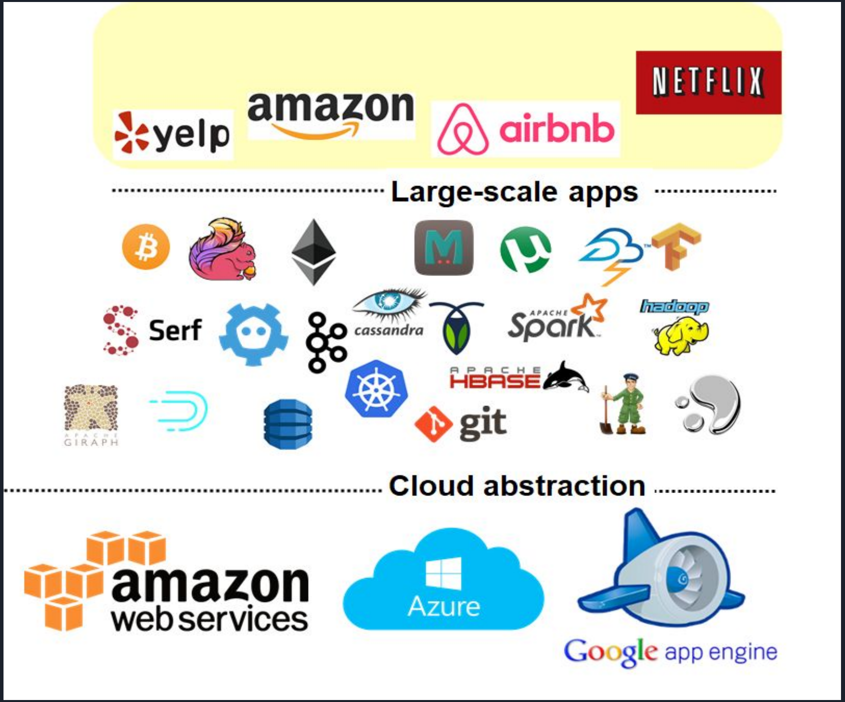
▶️ ***“A distributed system is one in which the failure of a computer you didn't even know existed can render your own computer unusable.”***

- Leslie Lamport

Distributed Systems are everywhere

- Distributed systems are widely deployed [1]

- Graph processing
- Stream processing
- Distributed databases
- Failure detectors
- Cluster schedulers
- Version control
- ML frameworks
- Blockchains
- KV stores
- ...



[1] Mark **Cavage**. 2013. *There's Just No Getting around It: You're Building a Distributed System*. Queue 11, 4, Pages 30 (April 2013)

Need for Observability: Ability to answer questions

- Which nodes/services did the request go through?
- Where were the bottlenecks for the request?
- What happened at every node/service to process the request?
- Where did the errors happen?

- How different was the execution of 1 request?
- How do different groups of requests differ?
- Axes for differences
    - Structural
    - Performance
- Root cause analysis

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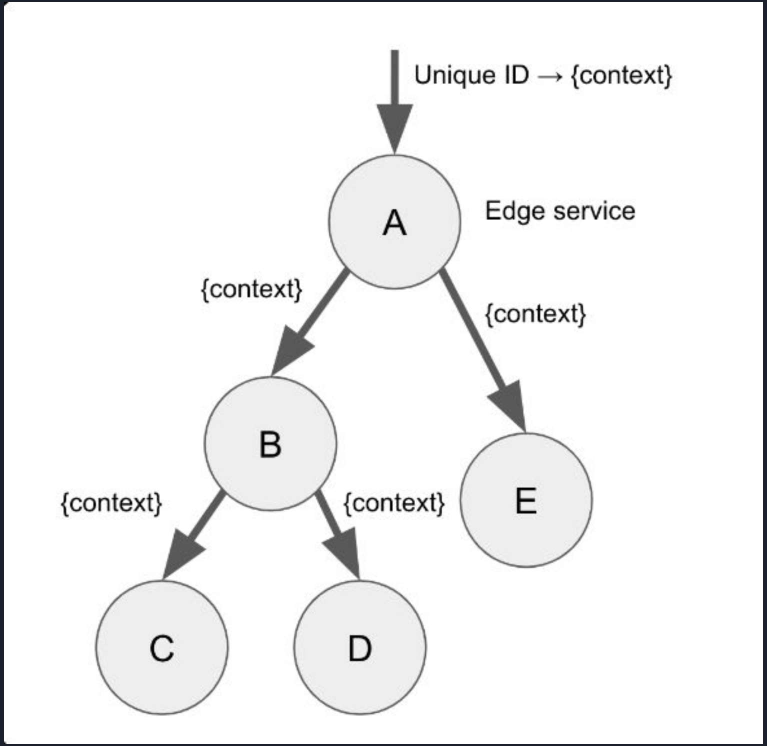
Distributed tracing can answer these questions

What is Distributed Tracing?



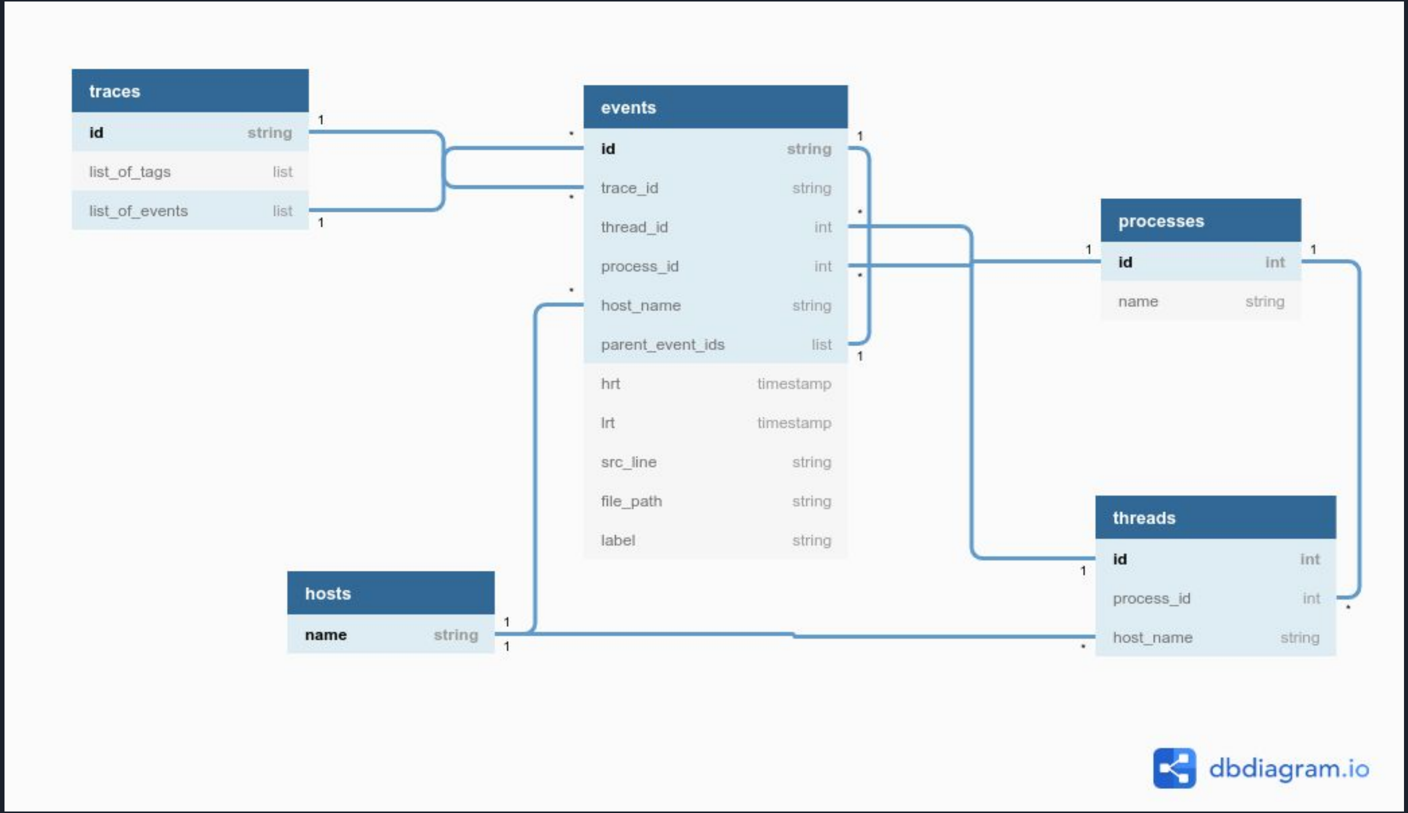
- Each trace represents path of 1 request through the system
- Trace collects and contains timing info, events across nodes, processes, and threads.
- Depending on verbosity, may also contain stack traces.

“Story of a request through a system”

Datasets

- 2 Trace Datasets & respective source code
  - DeathStarBench : https://github.com/delimitrou/DeathStarBench (Modified Version : https://gitlab.mpi-sws.org/cld/systems/deathstarbench)
  - Hadoop : https://gitlab.mpi-sws.org/cld/systems/hadoop
- DSB : 22390 traces
- Hadoop : 72030 traces

Data Abstraction



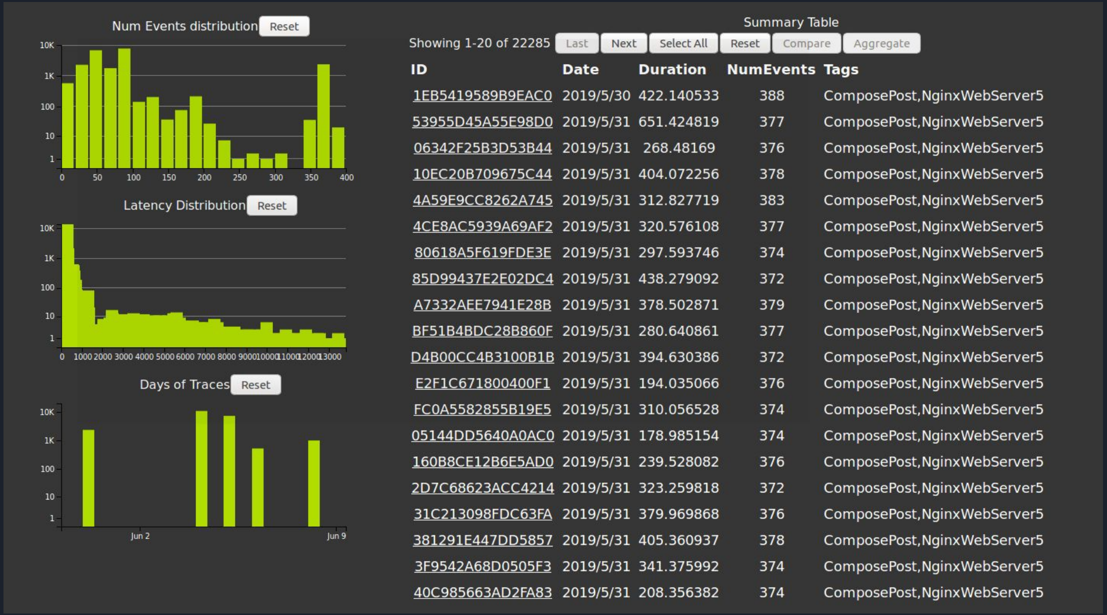
Tasks

- Outlier Finding + Overview of Dataset
- Source Code Integration
- Timing analysis of a single trace
- Service dependency analysis
- Comparison of 2 traces
- Aggregation of multiple traces

DEMO

Outlier finding + overview

- What: data
  - Traces
- Why: tasks
  - Find outliers and patterns
- How: reduce
  - Filter items using # events, duration, and day attributes
- How: show
  - Sortable and filtered table with traces



Summary Table

Showing 1-20 of 22285

ID	Date	Duration	NumEvents	Tags
1EB5419589B9EAC0	2019/5/30	422.140533	388	ComposePost,NginxWebServer5
53955D45A55E98D0	2019/5/31	651.424819	377	ComposePost,NginxWebServer5
06342F25B3D53B44	2019/5/31	268.48169	376	ComposePost,NginxWebServer5
10EC20B709675C44	2019/5/31	404.072256	378	ComposePost,NginxWebServer5
4A59E9CC8262A745	2019/5/31	312.827719	383	ComposePost,NginxWebServer5
4CE8AC5939A69AF2	2019/5/31	320.576108	377	ComposePost,NginxWebServer5
80618A5F619FDE3E	2019/5/31	297.593746	374	ComposePost,NginxWebServer5
85D99437E2E02DC4	2019/5/31	438.279092	372	ComposePost,NginxWebServer5
A7332AEE7941E28B	2019/5/31	378.502871	379	ComposePost,NginxWebServer5
BF51B4BDC28B860F	2019/5/31	280.640861	377	ComposePost,NginxWebServer5
D4B00CC4B3100B1B	2019/5/31	394.630386	372	ComposePost,NginxWebServer5
E2F1C671800400F1	2019/5/31	194.035066	376	ComposePost,NginxWebServer5
FC0A5582855B19E5	2019/5/31	310.056528	374	ComposePost,NginxWebServer5
05144DD5640A0AC0	2019/5/31	178.985154	374	ComposePost,NginxWebServer5
160B8CE12B6E5AD0	2019/5/31	239.528082	376	ComposePost,NginxWebServer5
2D7C68623ACC4214	2019/5/31	323.259818	372	ComposePost,NginxWebServer5
31C213098FDC63FA	2019/5/31	379.969868	376	ComposePost,NginxWebServer5
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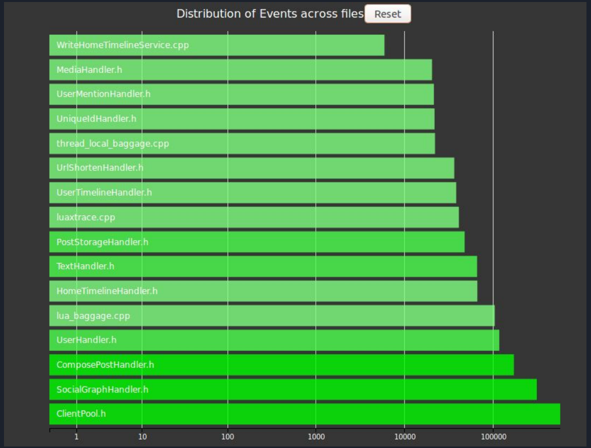
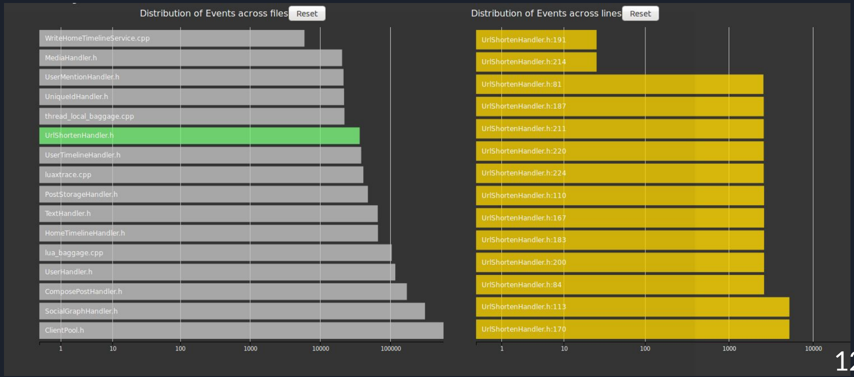
40C985663AD2FA83	2019/5/31	208.356382	374	ComposePost,NginxWebServer5

Source code relationship

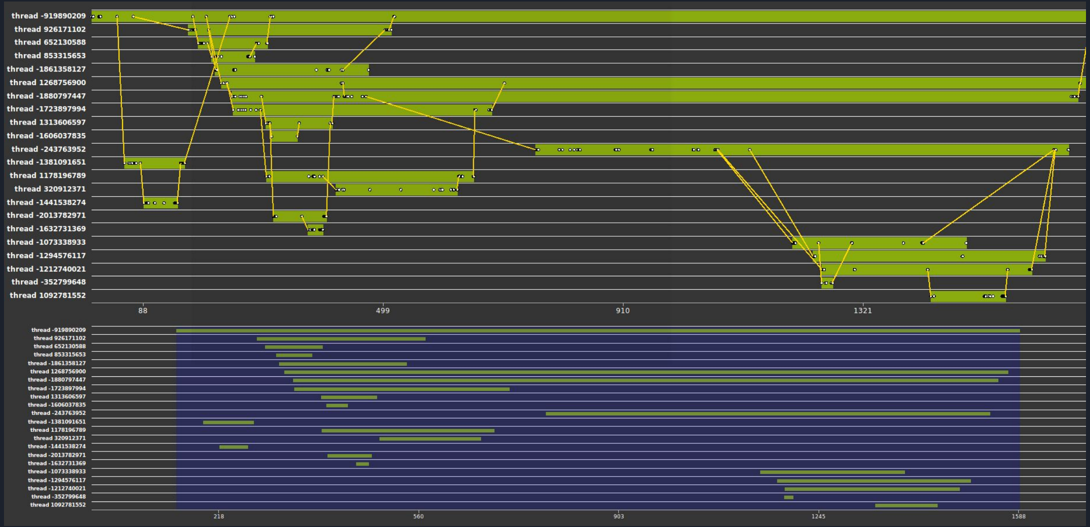
- What: data
  - Traces
- What: derived attrs
  - # Events triggered by each line of code
- Why:
  - What files are producing events
  - What lines in a file produced the most or least events
- How: aggregate
  - Aggregate # events from all src code lines in a file
- How: encode
  - Encode number of events or number of lines with size of bar
  - Encode number of events or number of lines with colour of bar





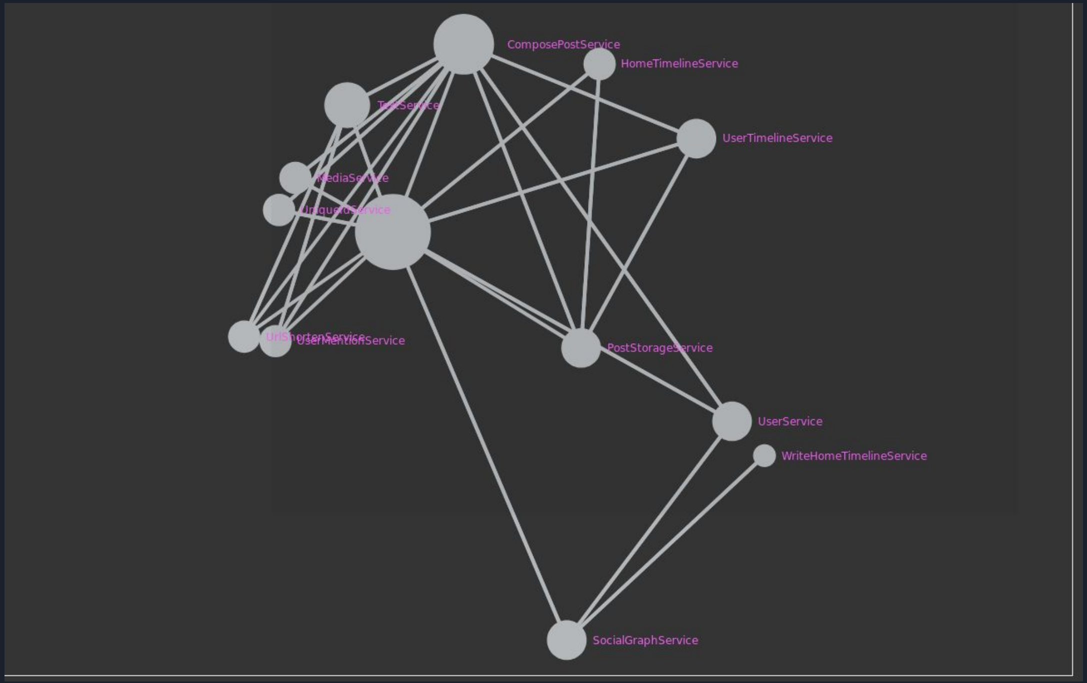
Show an individual trace

- What: data
  - 1 trace
- Why:
  - Look at time of events in a trace related to each other
  - Find parent and child relationships between events
- How: encode
  - Encode each thread as a lane
  - Encode time of event as position on x-axis
  - Encode thread of event as position on y-axis
  - Encode parent/child relationships with connecting lines



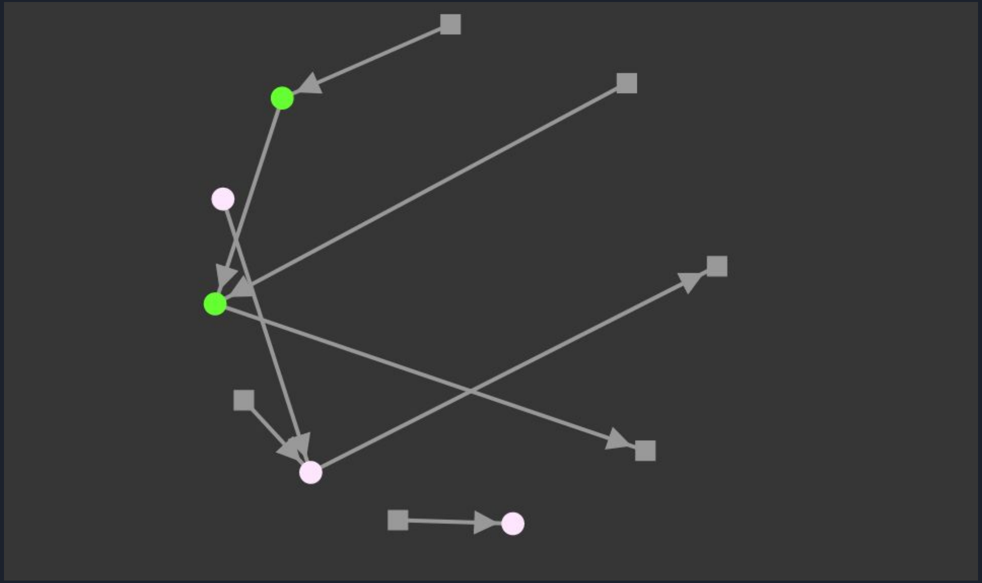
Dependency Graph

- What: derived items
  - Total messages issued by a service
- Why:
  - Understand dependency relationship between services
- How: arrange services into a node-link graph
  - Service is a node
  - Dependency is a link between nodes
- How: encode
  - Encode degree of a node with area of circle



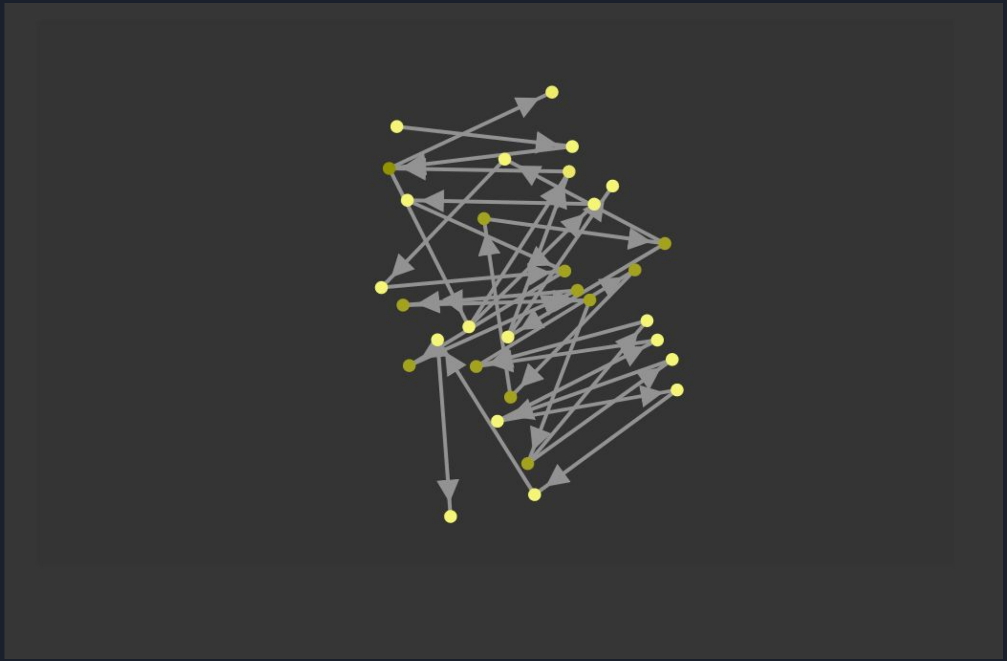
Compare

- What: data
  - 2 traces
- What: derived
  - For each event add it to group between 1-3
- Why: find difference between traces
- How: arrange events into a node-link graph
  - Event is a node
  - Link is parent-child relationship between nodes
- How: encode
  - Encode group 3 nodes as squares and groups 1-2 as circles
  - Encode group of event by node colour
- How: aggregate
  - Aggregate group 3 nodes so that it maintains its structure



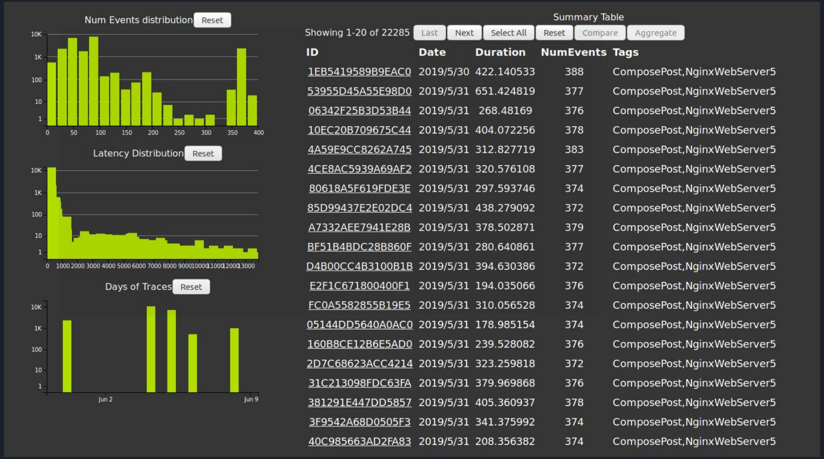
Aggregate

- What: data
  - Traces
- Why: see the big picture
- How: arrange events into a node-link graph
  - Event is a node
  - Link is parent-child relationship between nodes
- How: aggregate
  - Aggregate events from same source code line
- How: encode
  - Encode number of events in a node with luminance
    - High luminance = many events
    - Low luminance = few events



Discussion

- Overview page provides a nice way of exploring the trace dataset.
- First viz tool to provide source code integration for distributed traces.
- Graph layouts are not great. Suffer from hairball effect.
- The compare and aggregate idioms are confusing for users.



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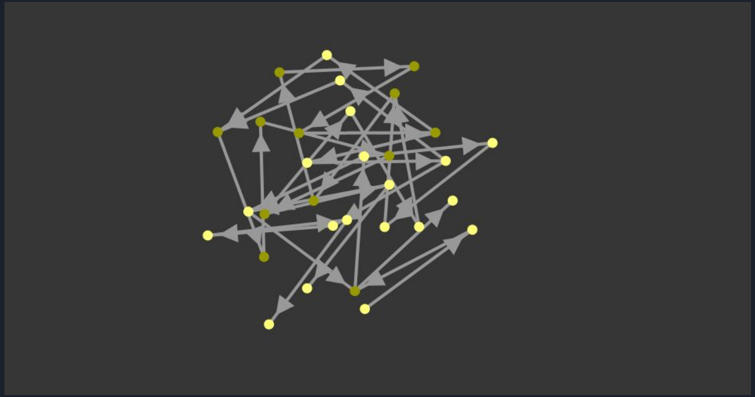
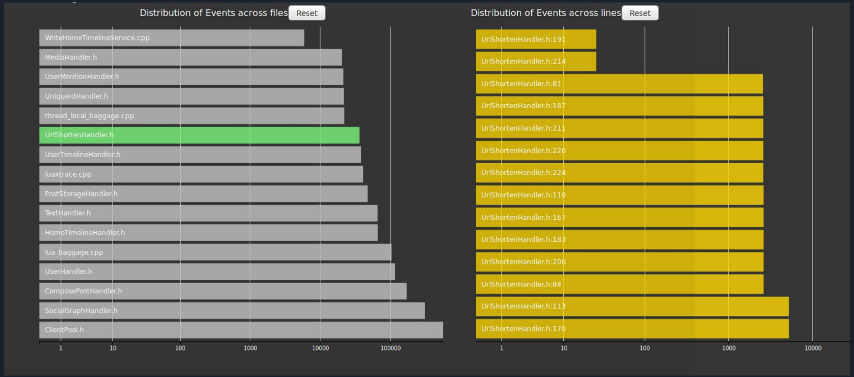
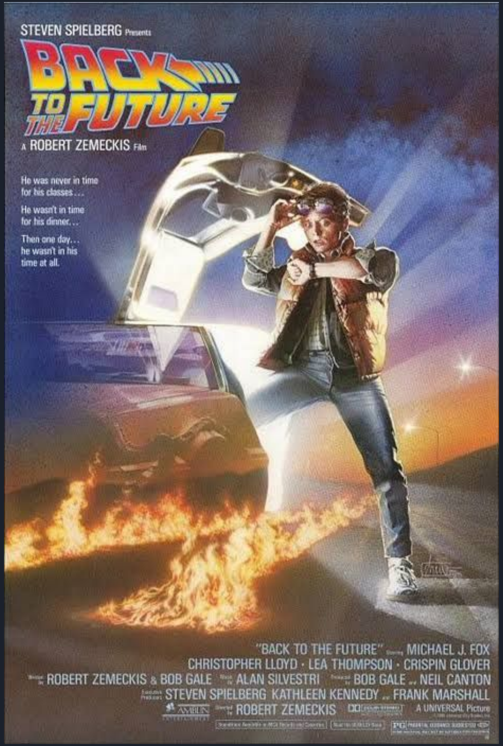




Future Work

- Better layouts for graph visualizations to remove hairball effect
- Add detail view for swimlane
- Add viz idiom for comparing 1 trace against an aggregation of traces
- Add viz idiom for comparing 2 different aggregation of traces
- Integrate/Replace existing tools :)
- Usability Study
- Integrate it with backend server of X-Trace tracing system.


STEVEN SPIELBERG Presents
BACK TO THE FUTURE
A ROBERT ZEMECKIS Film
He was never in time for his classes...
He wasn't in time for his dinner...
Then one day... he wasn't in his time at all.
"BACK TO THE FUTURE" MICHAEL J. FOX
CHRISTOPHER LLOYD · LEA THOMPSON · CRISPIN GLOVER
ROBERT ZEMECKIS & BOB GALE ALAN SILVESTRI BOB GALE NEIL CANTON
STEVEN SPIELBERG KATHLEEN KENNEDY FRANK MARSHALL
ROBERT ZEMECKIS A UNIVERSAL Picture