Filtering based on process ranking

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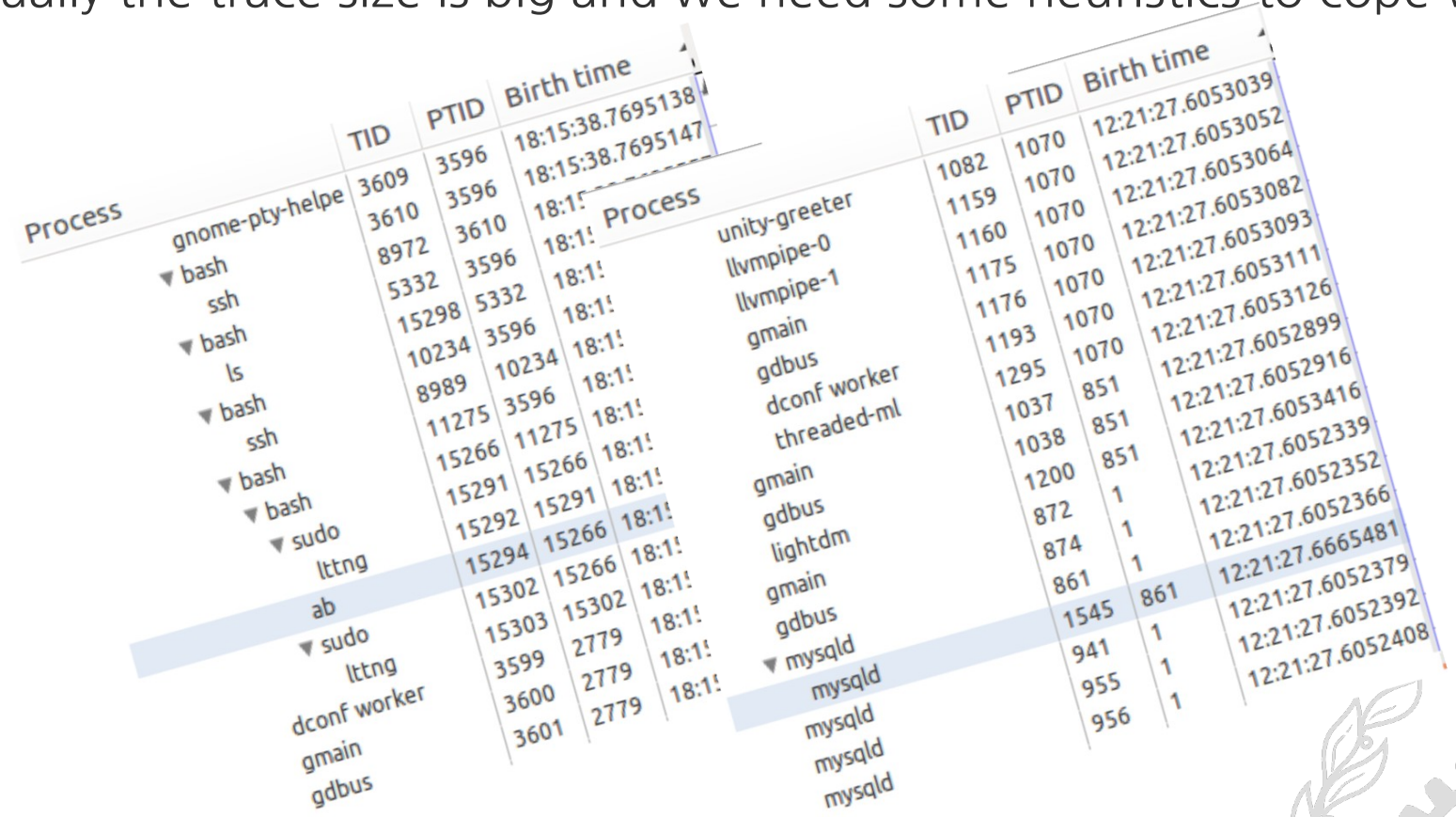
Introduction

Tracing is used for performance analysis and debugging.

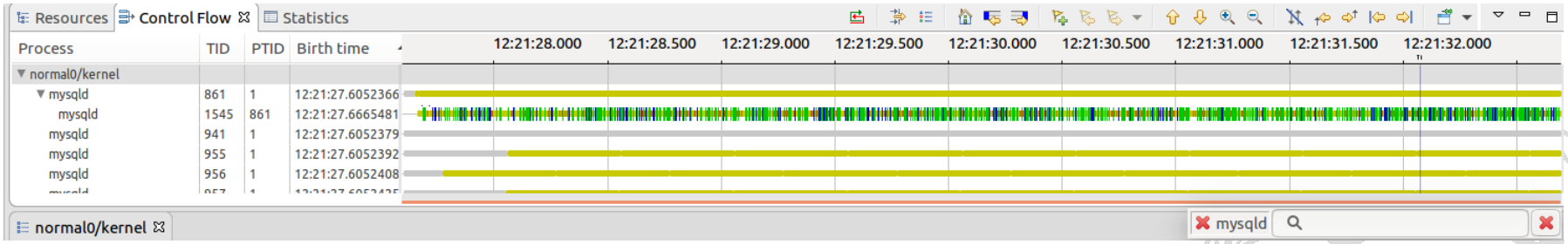
Usually the trace size is big and we need some heuristics to cope with it.



Current methods

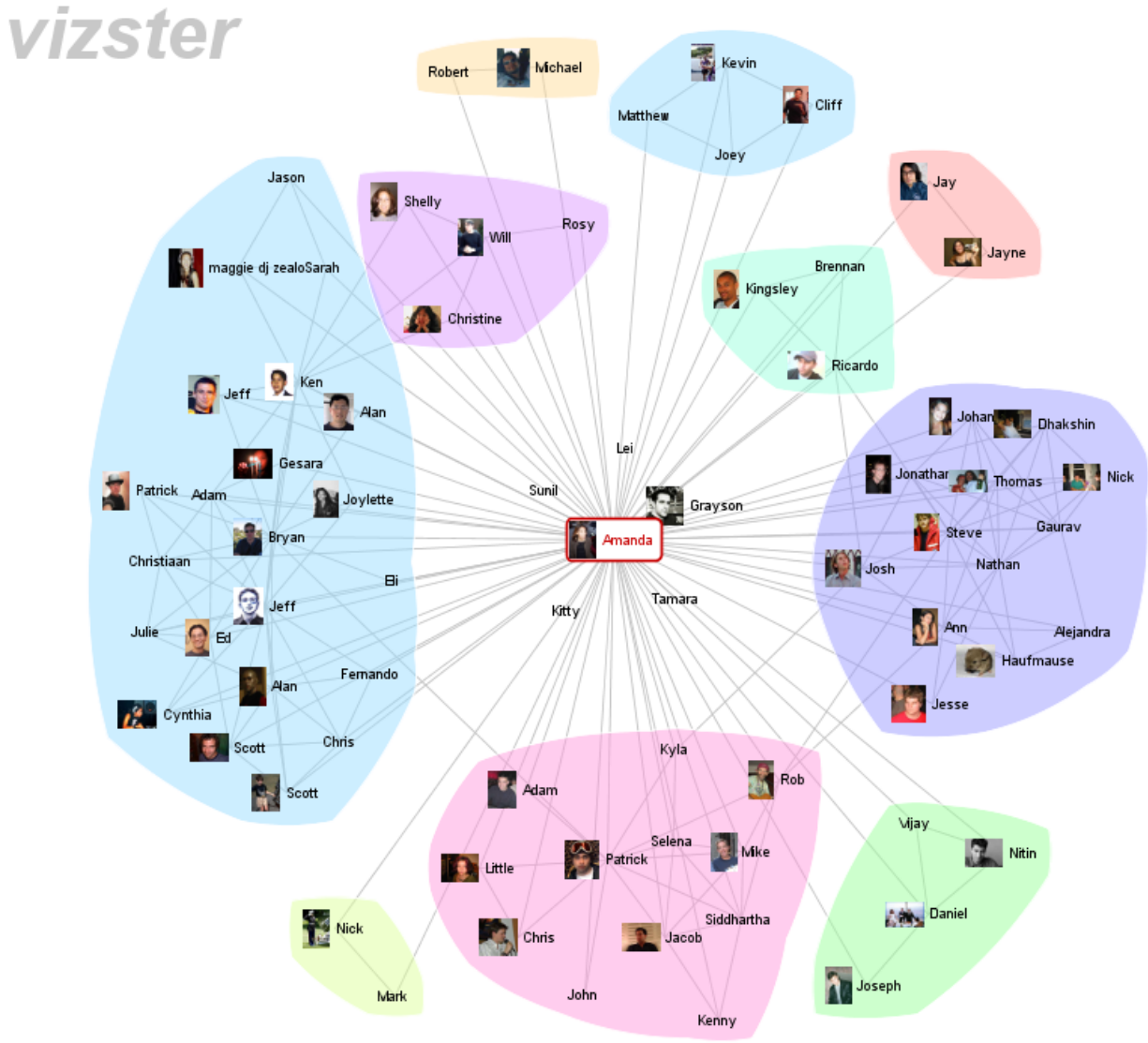
- Sampling or event filtering.
- Time view filtering.
- Global filtering

Timestamp	Channel	CPU	Event type	Contents
<srch>	<srch>	<srch>	<srch>	tid=861
12:21:27.650 850 349	more-subbuf_0	0	syscall_entry_connect	fd=3, uservaddr=0x7ffe5564c030, addrlen=0x6e, family=1, dport=0, _v4addr_length=0, v4addr=[], _v6addr_length=0, v6addr=[], contex
12:21:27.650 863 113	more-subbuf_0	0	sched_waking	comm=mysqld, tid=861, prio=20, target_cpu=0, context._tid=1544, context._pid=1544, context._procname=sysbench
12:21:27.650 868 663	more-subbuf_0	0	sched_wakeup	comm=mysqld, tid=861, prio=20, target_cpu=0, context._tid=1544, context._pid=1544, context._procname=sysbench
12:21:27.650 870 198	more-subbuf_0	0	syscall_exit_connect	ret=0, context._tid=1544, context._pid=1544, context._procname=sysbench
12:21:27.650 873 554	more-subbuf_0	0	sched_switch	prev_comm=sysbench, prev_tid=1544, prev_prio=20, prev_state=0, next_comm=mysqld, next_tid=861, next_prio=20, context._tid=154
12:21:27.650 886 455	more-subbuf_0	0	syscall_exit_poll	ret=1, nfds=2, fds_length=1, fds=[[fd=23, raw_events=0x1, events._POLLIN=1, events._POLLPRI=0, events._POLLOUT=0, events._POLL
12:21:27.650 895 764	more-subbuf_0	0	syscall_entry_accept	fd=23, upeer_sockaddr=0x7fffd9470d50, upeer_addrlen=128, context._tid=861, context._pid=861, context._procname=mysqld
12:21:27.650 904 076	more-subbuf_0	0	syscall_exit_accept	ret=39, upeer_addrlen=2, family=1, sport=0, _v4addr_length=0, v4addr=[], _v6addr_length=0, v6addr=[], context._tid=861, context._pi
12:21:27.650 918 648	more-subbuf_0	0	syscall_entry_futex	uaddr=31402148, op=133, val=1, utime=1, uaddr2=31402144, val3=67108865, context._tid=861, context._pid=861, context._procname=r
12:21:27.650 923 327	more-subbuf_0	0	sched_waking	comm=mysqld, tid=1291, prio=20, target_cpu=0, context._tid=861, context._pid=861, context._procname=mysqld
12:21:27.650 926 771	more-subbuf_0	0	sched_wakeup	comm=mysqld, tid=1291, prio=20, target_cpu=0, context._tid=861, context._pid=861, context._procname=mysqld
12:21:27.650 928 588	more-subbuf_0	0	syscall_exit_futex	ret=1, uaddr=31402148, uaddr2=31402144, context._tid=861, context._pid=861, context._procname=mysqld



Idea

Graph theory

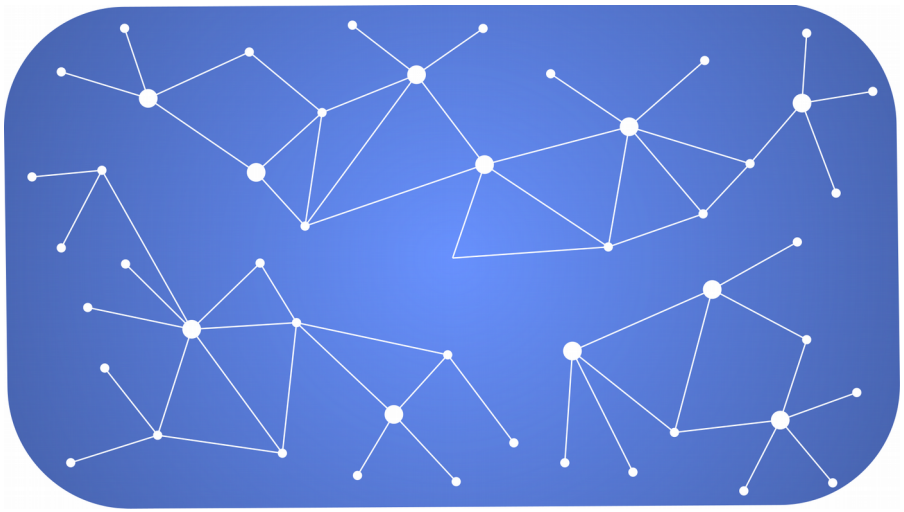


Picture from: http://vis.stanford.edu/jheer/projects/vizster/

Method

I.

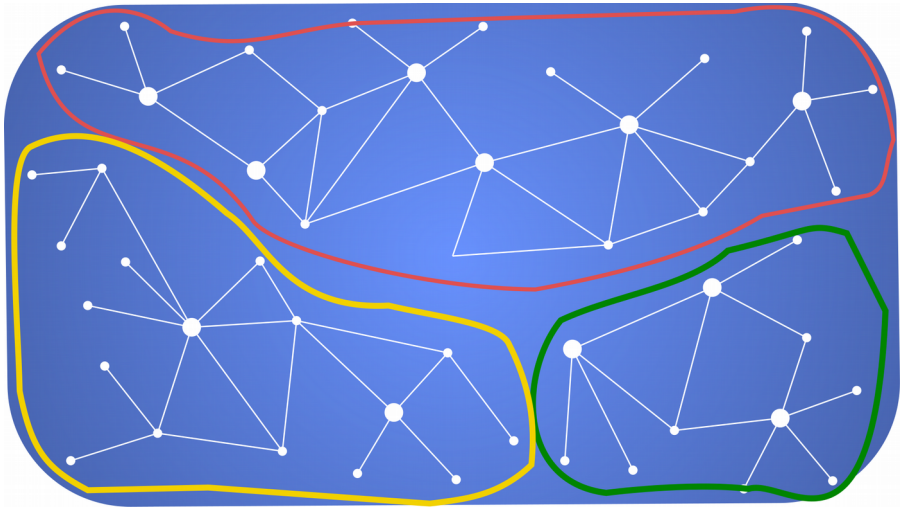
- Extract the processes interactions based on the execution graph.
- Building a graph G = (V,E)
- V includes all the processes running on the system
- E is a set of edges defined based on the interactions between the processes.



Method

II.

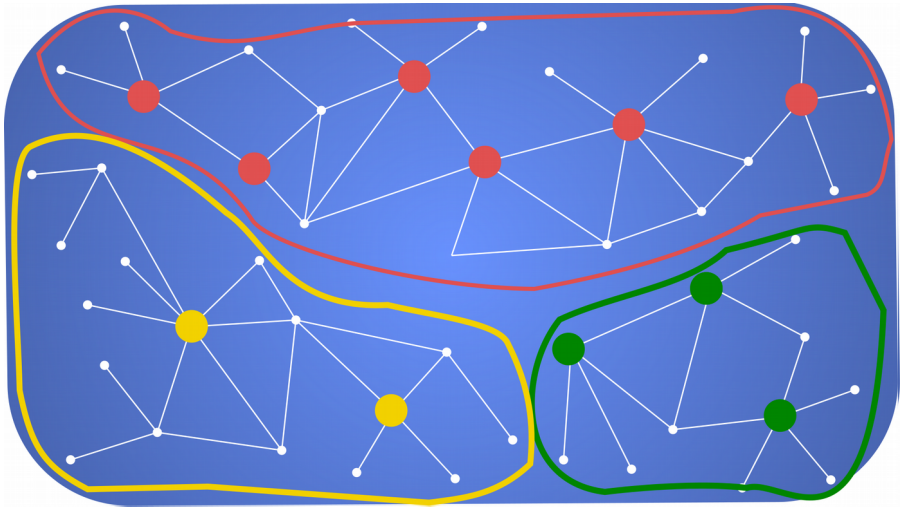
Compute connected components on the graph to extract all the subgraphs. (e.g., BFS)



Method

III.

- Apply a ranking algorithm on each connected component to assign a rank to each process
- Choose the top-K processes..

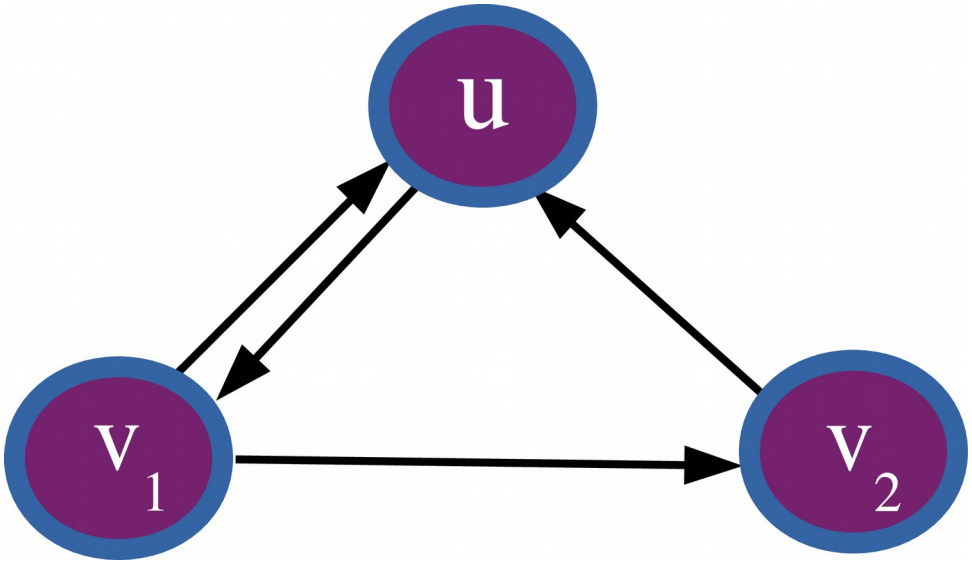


Method

Modified PageRank algorithm: Includes only **one** iteration

Node rank initialization: equal weights, or even CPU/IO usage

$$R(u) = c \sum_{v \in B_u} \frac{R(v)}{N_v}$$



u: a process

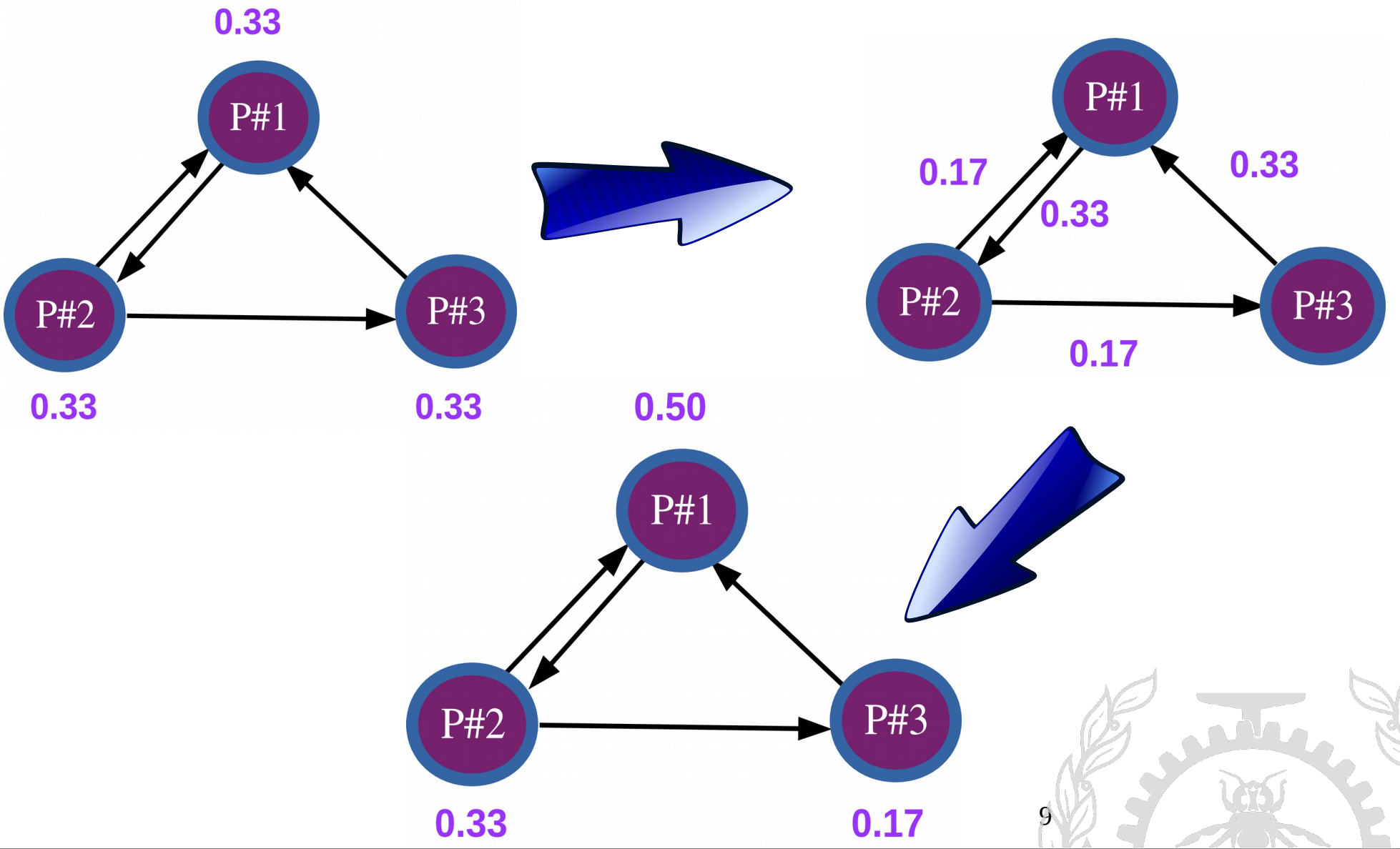
B_u: the set of u's in-edges

N_v: the number of out-edges of process v

c: the normalization factor

Method

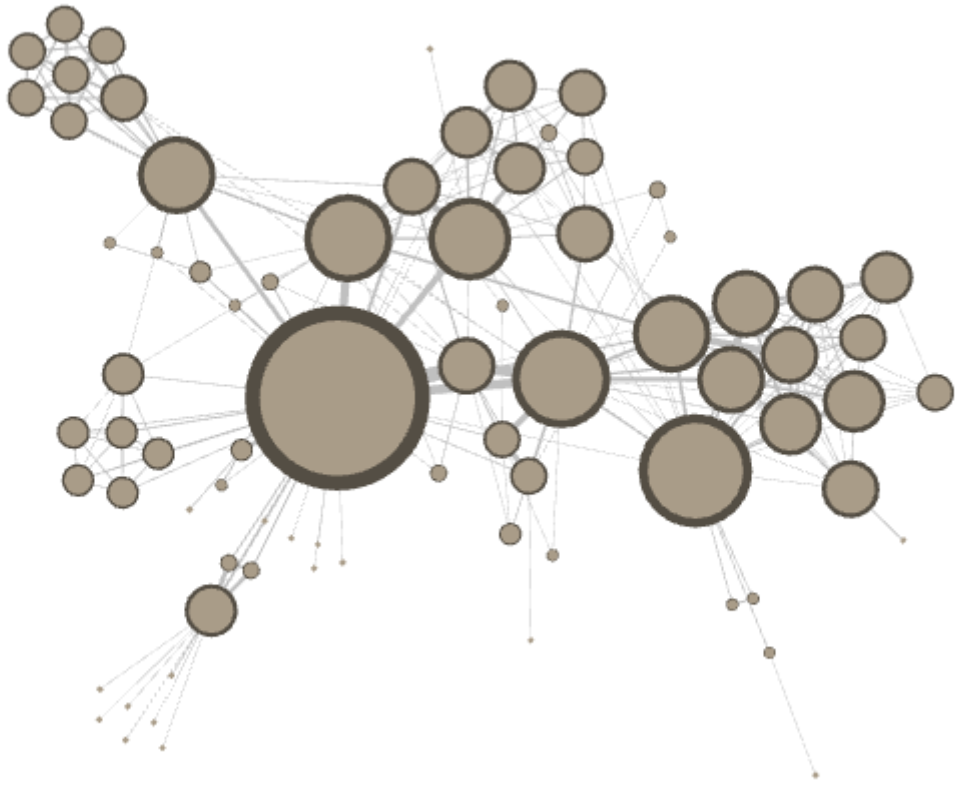
Modified PageRank algorithm:



Method

NB. Computing connected components on the graph

Other approaches:
e.g., Graph Modularity



Method

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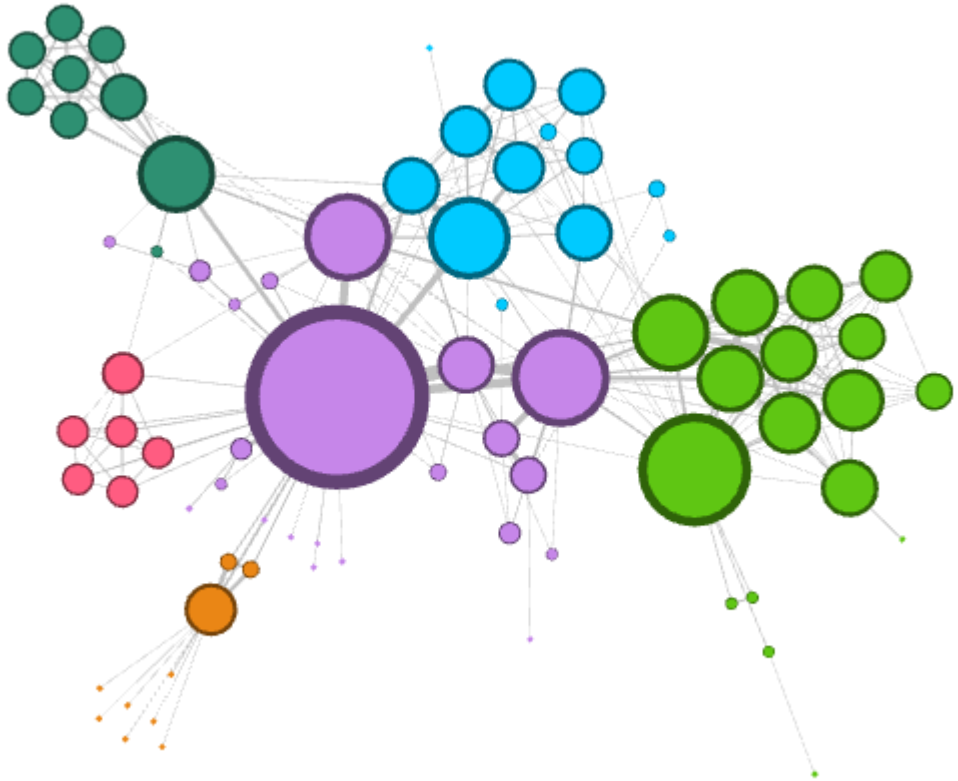


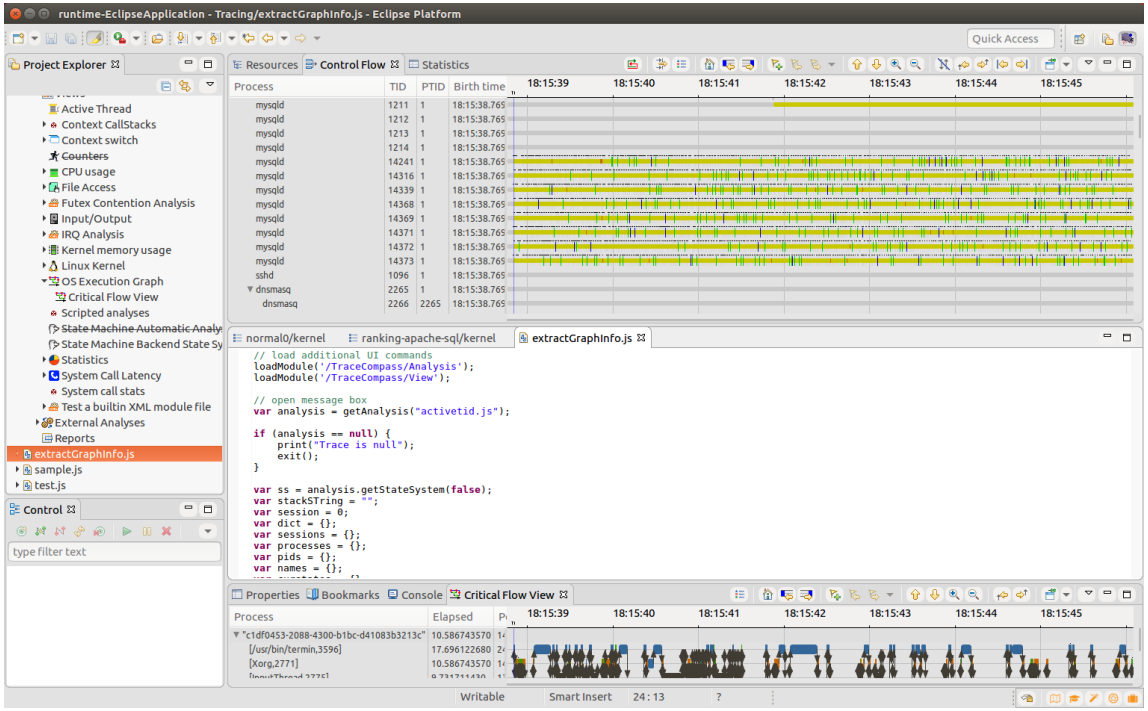
Use case I

Trace Compass:

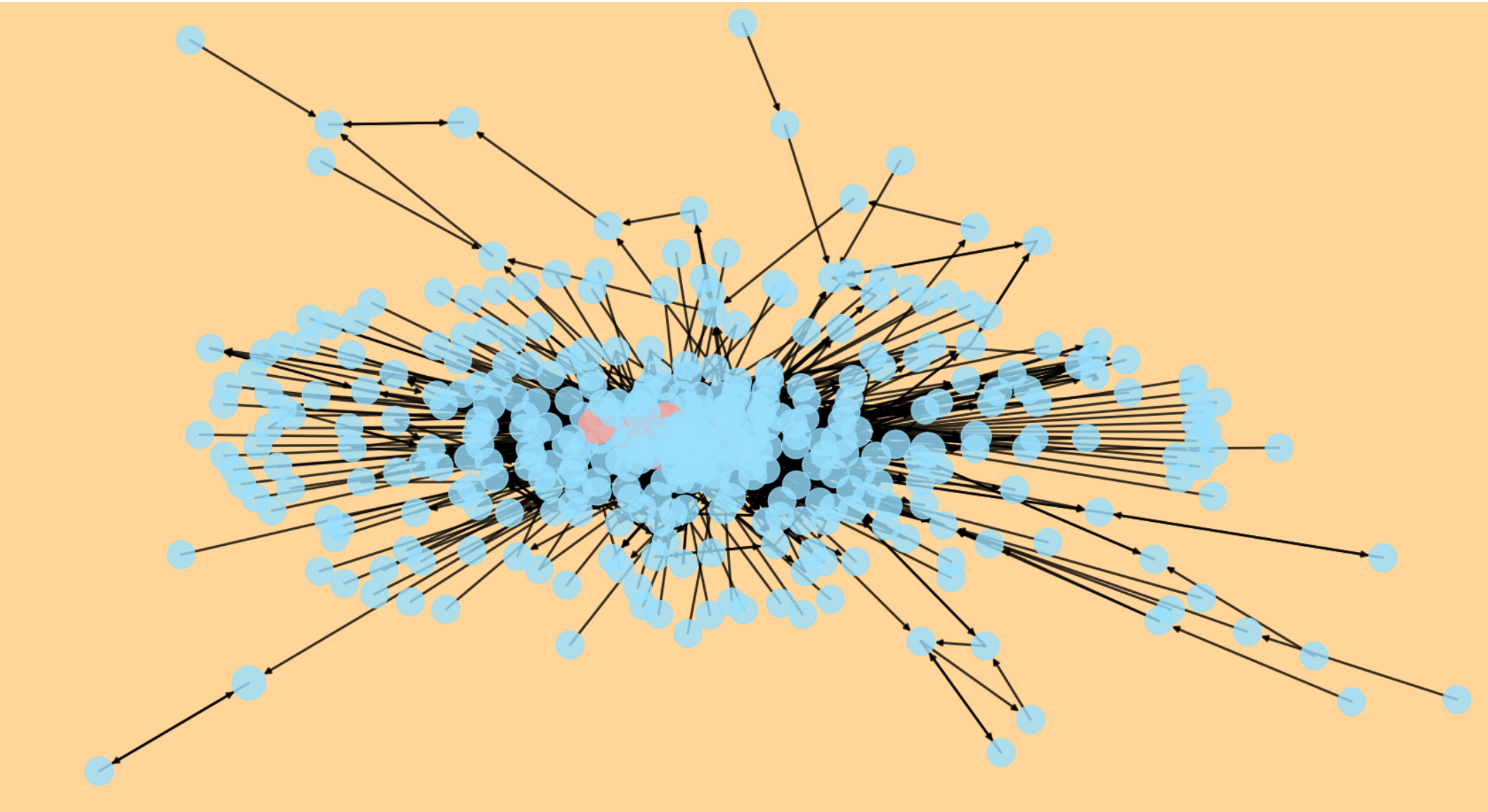
Extract process interactions using EASE scripting.

Providing a view showing top-ranked processes in each subgraph.

Filtering top-ranked processes in **event** view.

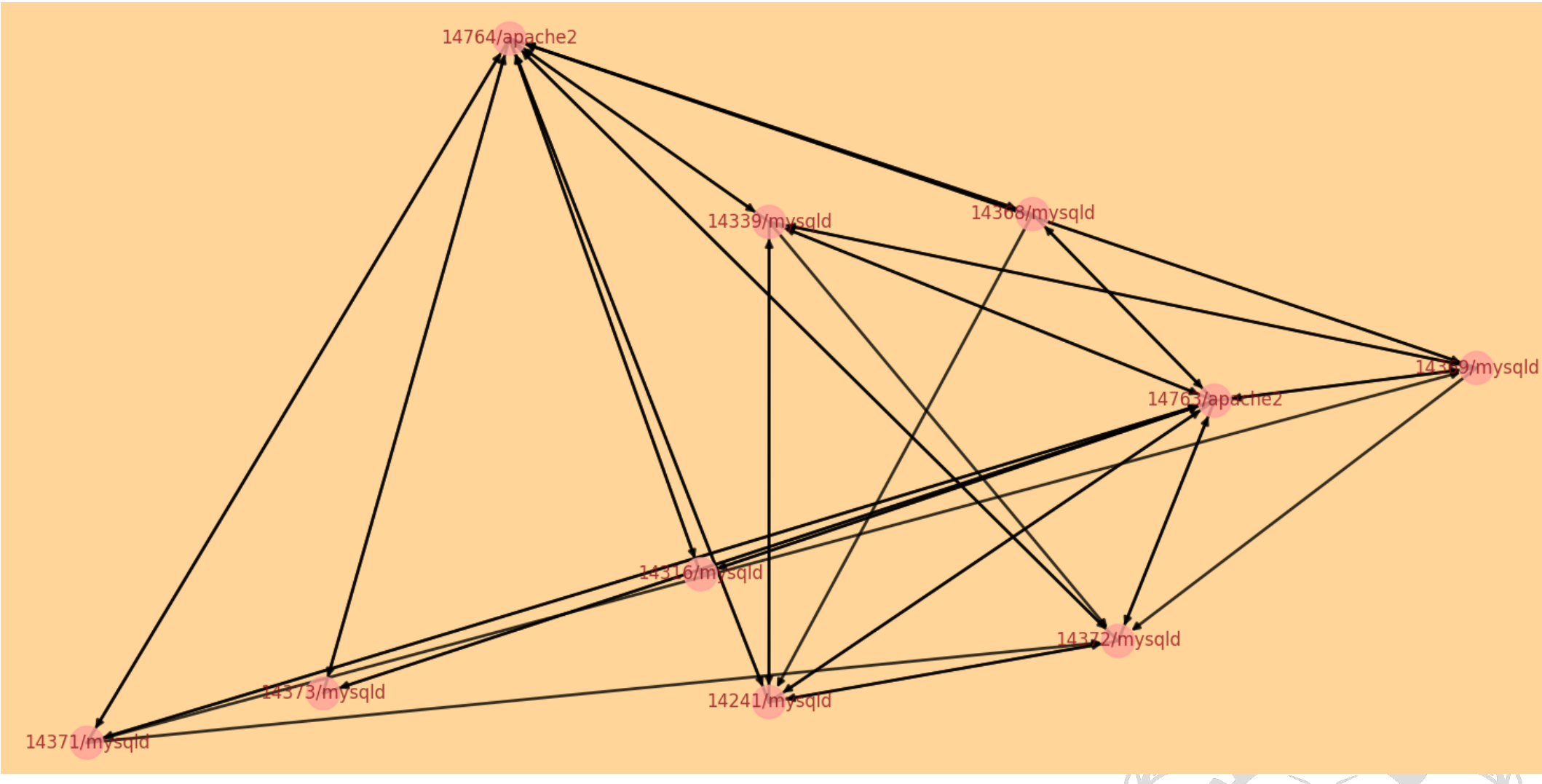


Use case I



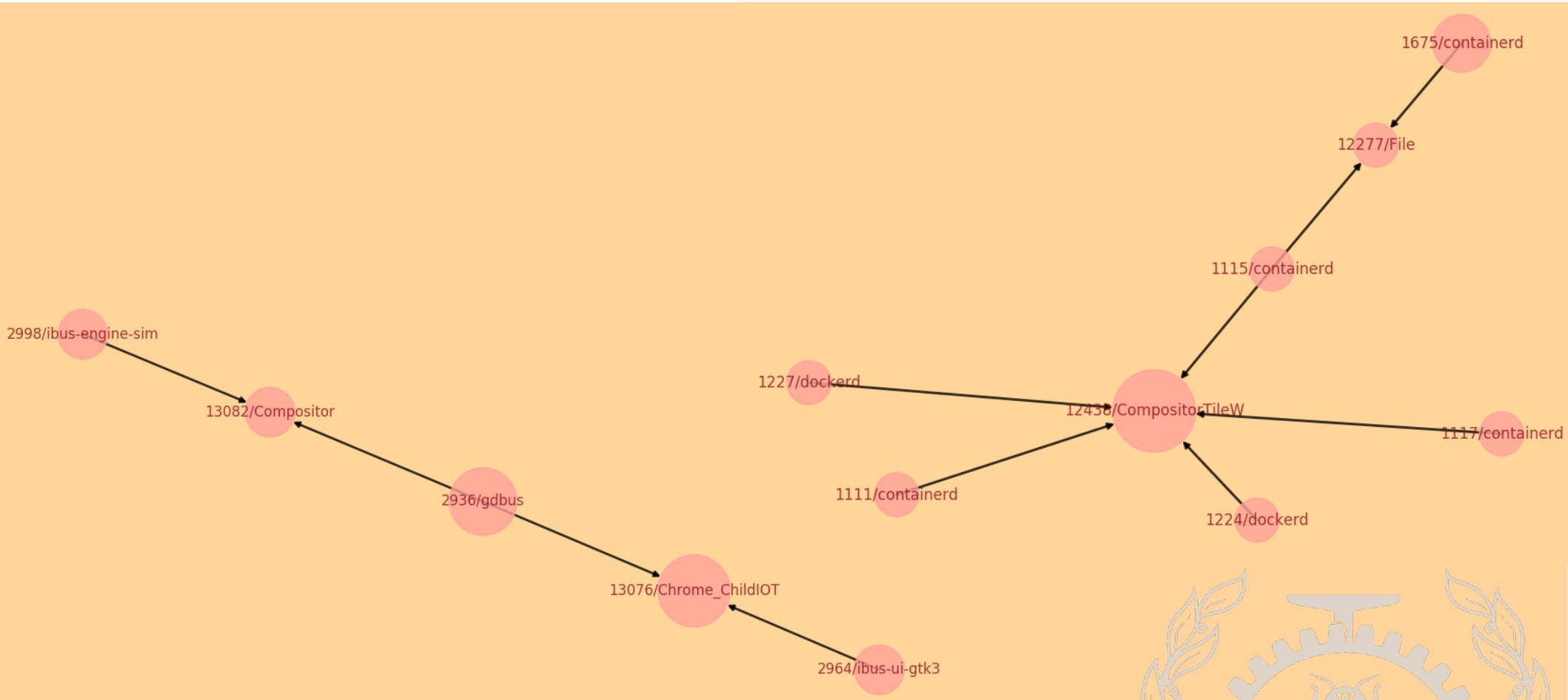
Use case I

Top-ranked processes in subgraph I



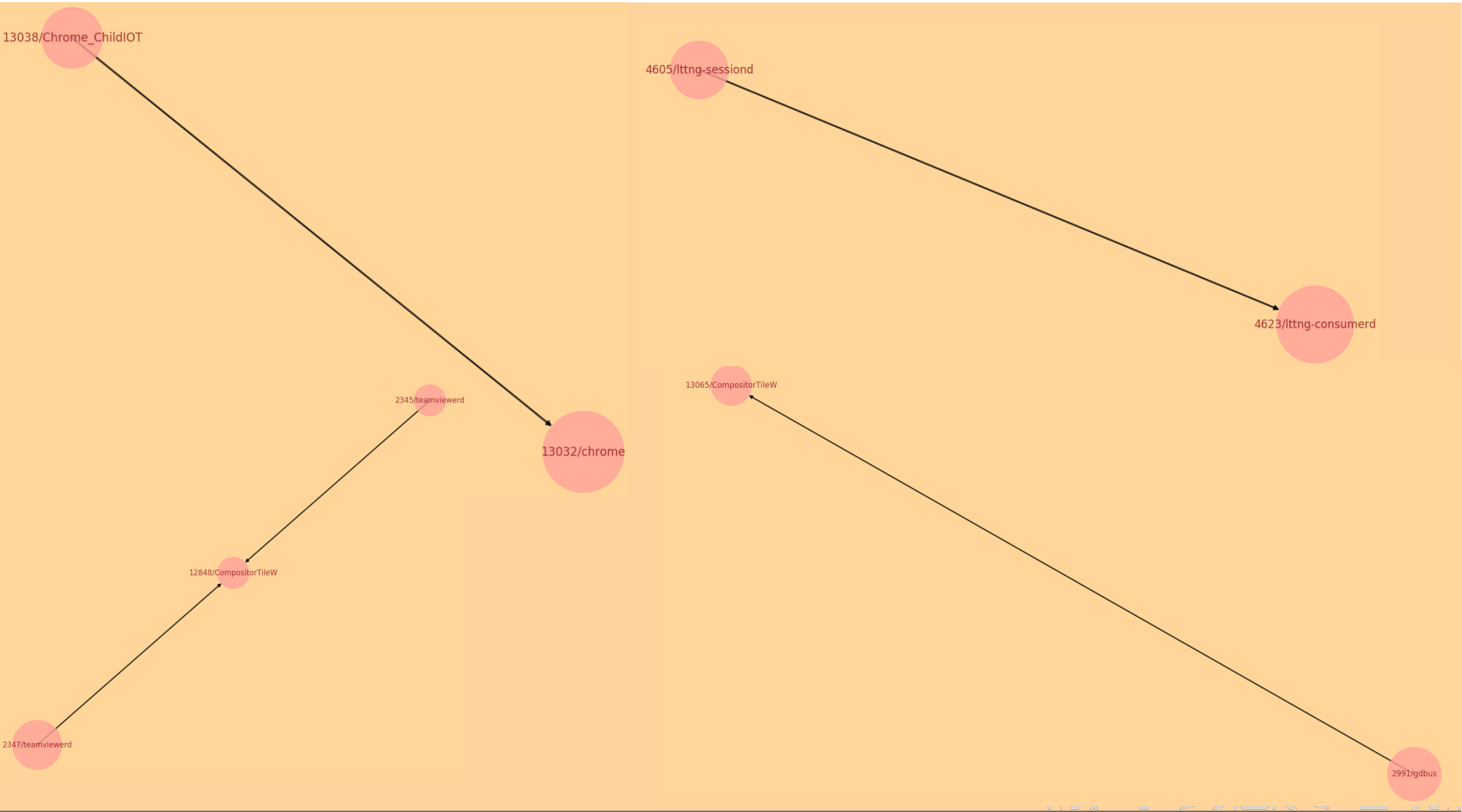
Use case I

Top-ranked processes in subgraph II and III



Use case I

Top-ranked processes in other subgraphs:

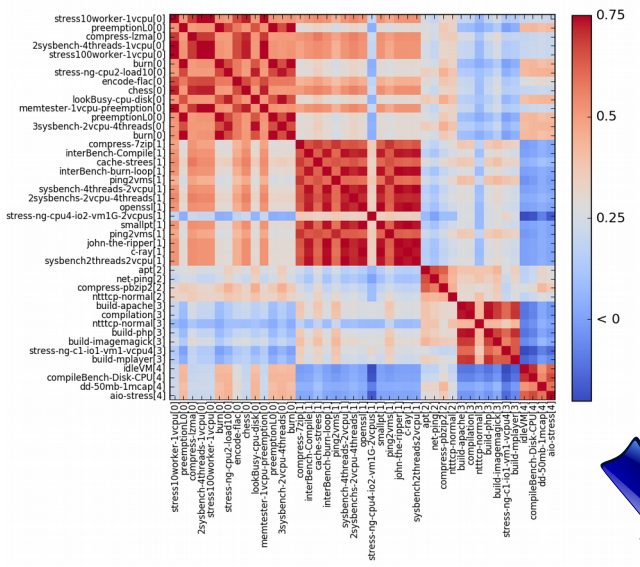


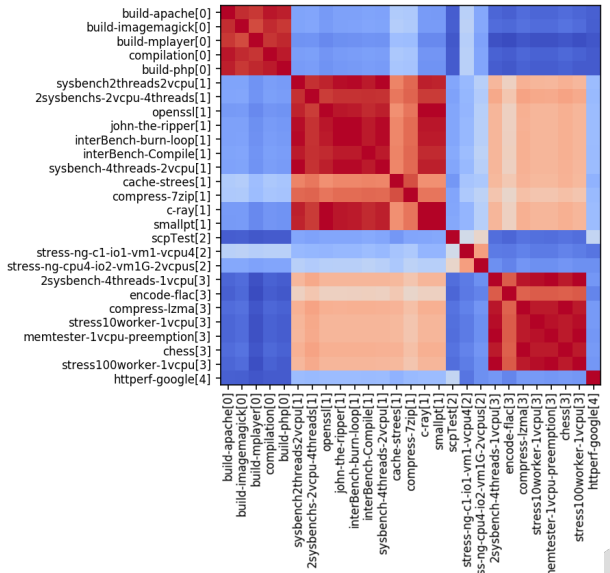
Use case II

VM clustering[1] :

Identifying the top important processes running on each VM.

Filtering out the irrelevant processes to provide a more distinct VM workload clustering.

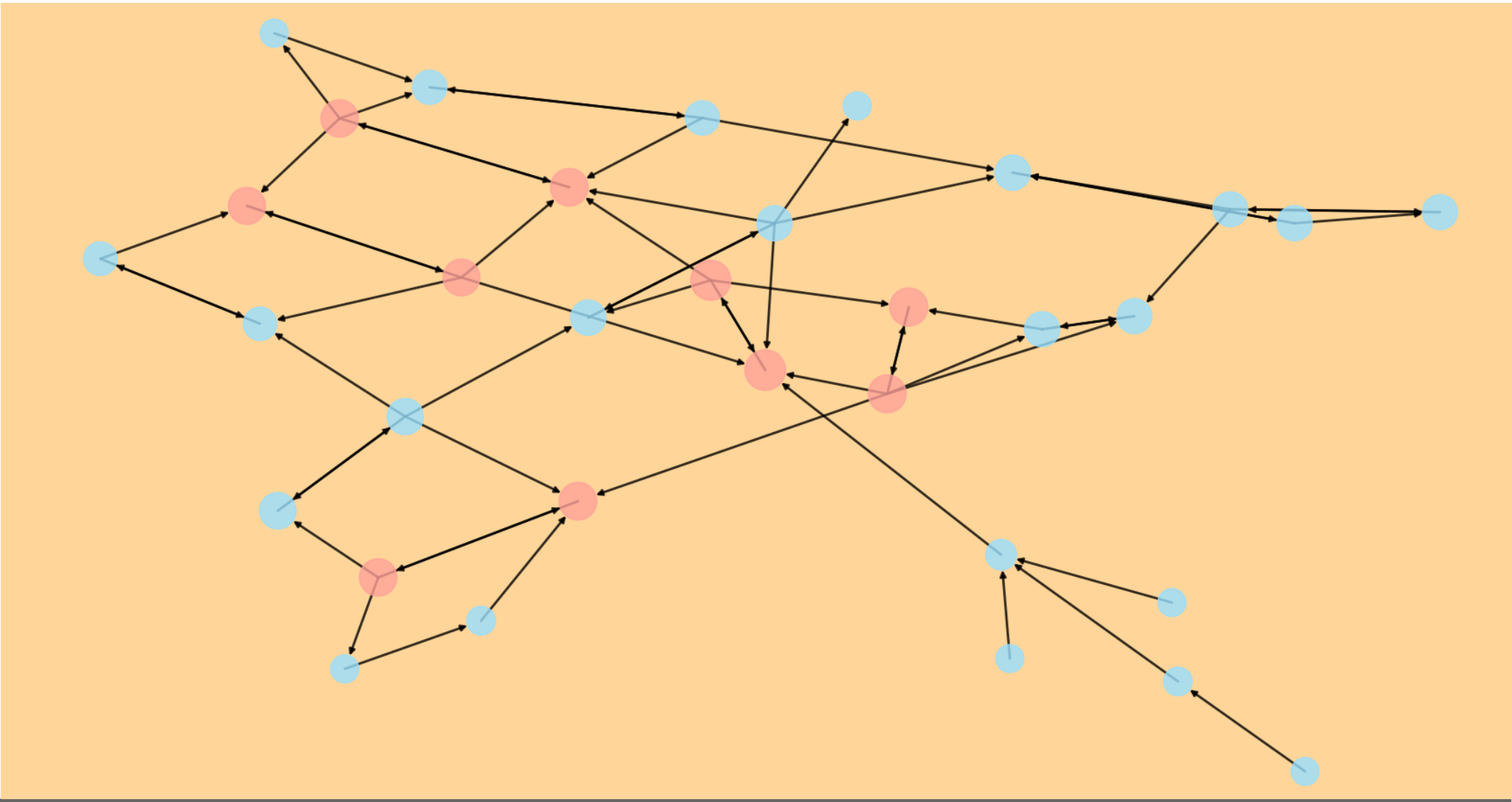




[1]Nemati H., Azhari V., et al., Host-based Virtual Machine Workload Characterization using Hypervisor Trace Mining, ACM Trans 2019

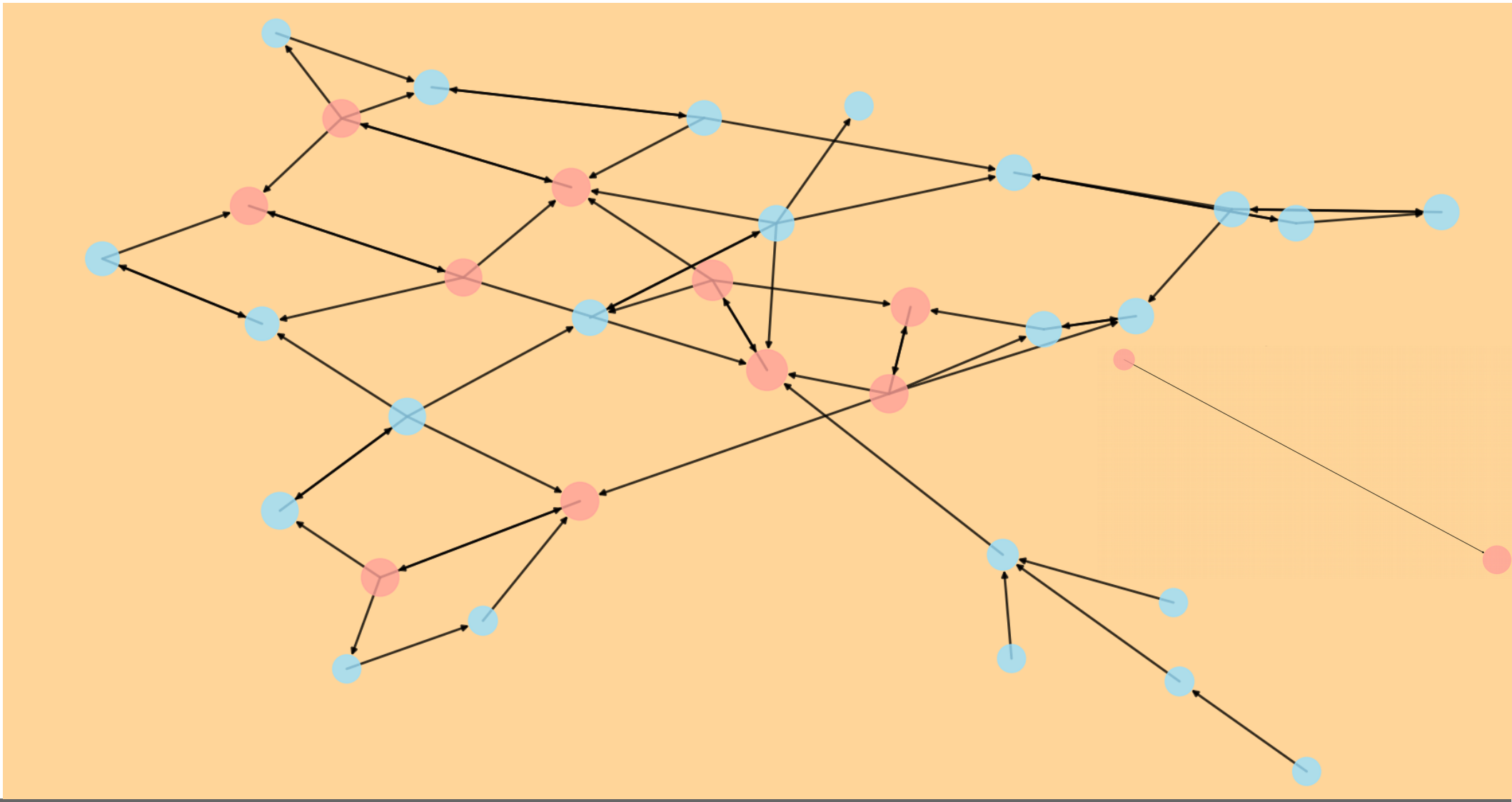
Use case II

Subgraph I:



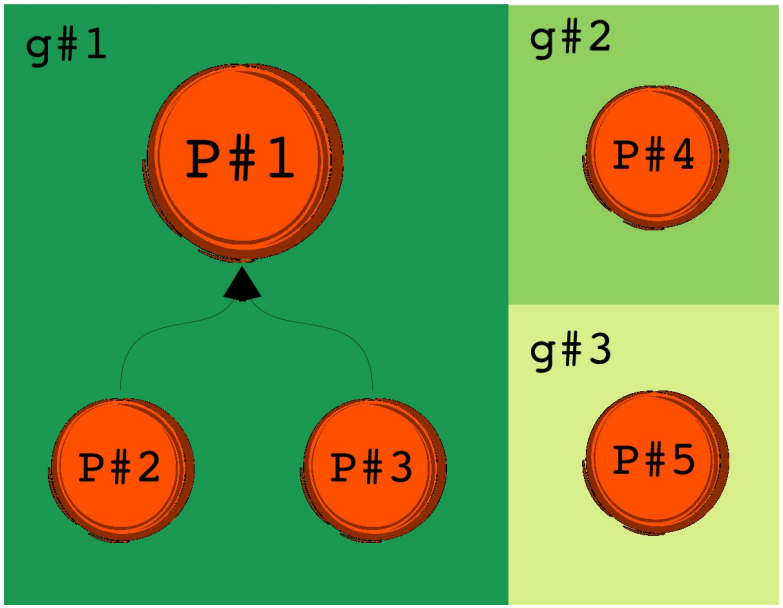
Use case II

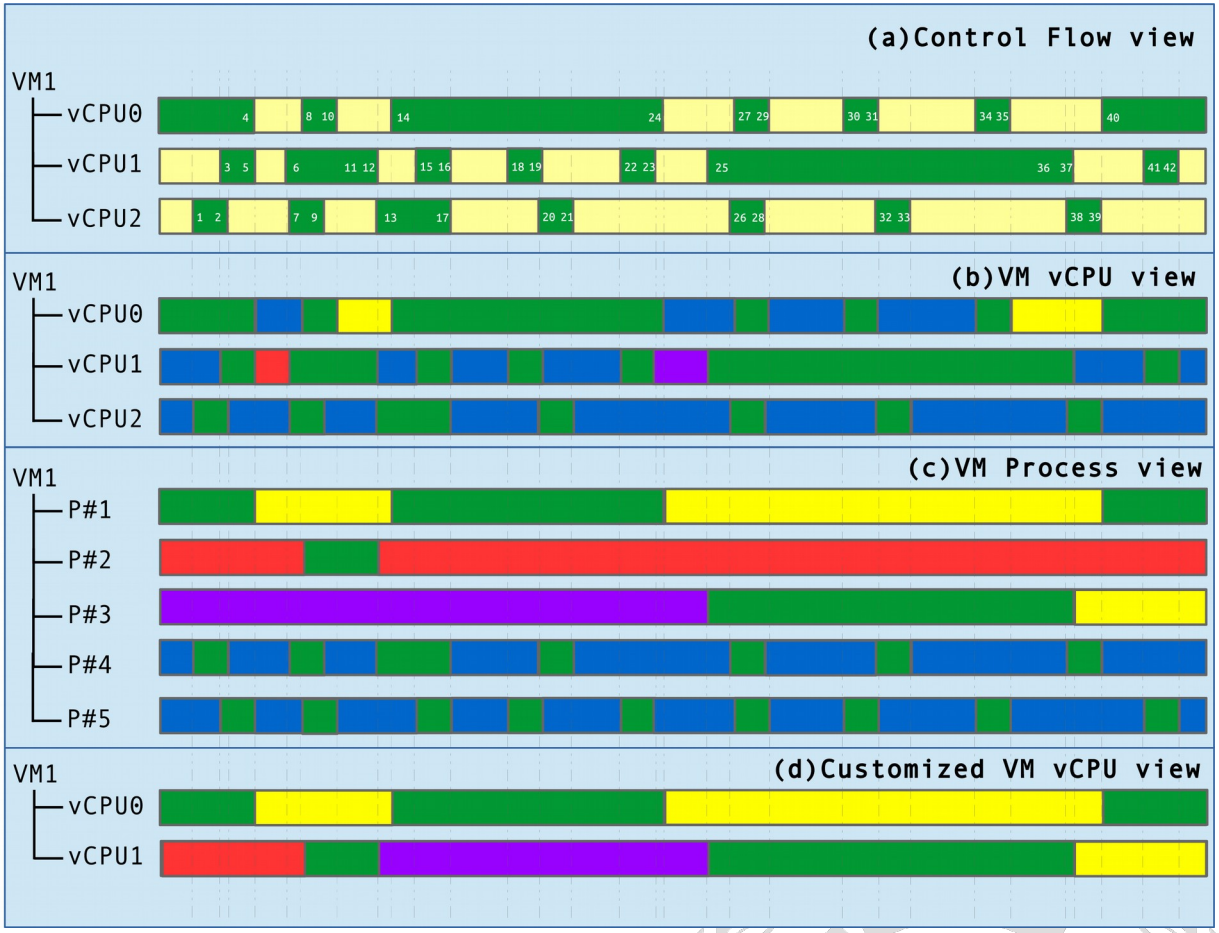
Subgraph I and II:



Use case II

- A **customized vCPU view** based on active processes
- **Example:**





Conclusions & Future work

- Filtering based on process ranking
- Top interacting processes in one system
- Interaction between VM's processes in a cloud environment
- Time-window feature extraction for machine learning applications
- Enhance graph structure analysis, e.g., graph modularity

Questions

Thanks for your attention!

Appendix

Appendix

- VM

Algorithm 2: Process Ranking Algorithm (PRA)

```
1  if event == sched_ttwu then
2      j = getVMvCPU(wakee_tid);
3      k = getVMvCPU(waker_tid);
4      wakerCR3 = getLastCR3(vCPU_k);
5      updateWaker(vCPU_j, wakerCR3);
6  else if event == vm_inj_virq then
7      j = getVMvCPU(tid);
8      pCR3 = getVMvCPU(vCPU_j);
9      if vec == IPI then
10         wakerCR3 = queryWaker(vCPU_j);
11         LINK_HORIZONTAL(wakerCR3, pCR3);
12 for all process cr3_i ∈ CR3 do
13     R(cr3_i);
14 connected_subgraph = breadth-first-search(CR3);
15 customized_graph = denoise(connected_subgraph, R(CR3));
```