TECHNISCHE UNIVERSITÄT DRESDEN
Center for Information Services and High Performance Computing

Edge Bundling for Visualizing Communication Behavior

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Slides and supplemental material:
https://github.com/hydroo/sc16-vpa-edge-bundling-for-visualizing-communication-behavior

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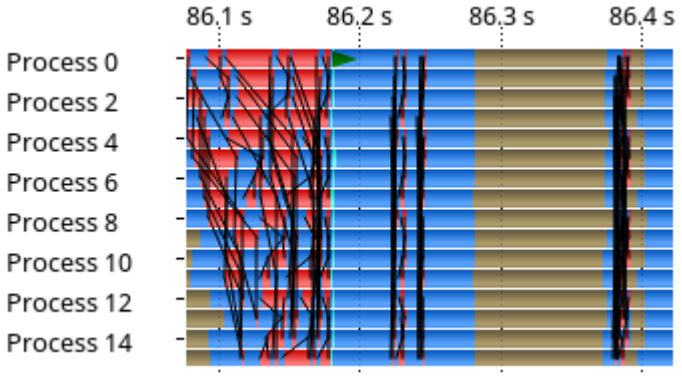
Introduction & Motivation

- Utilize today‘s computers → increasing concurrency
- HPC systems use distributed memory → inter-process communication (IPC) required (e.g. Message Passing)
- Analysis and visualization of IPC supports developers in their debugging and performance optimization workflows

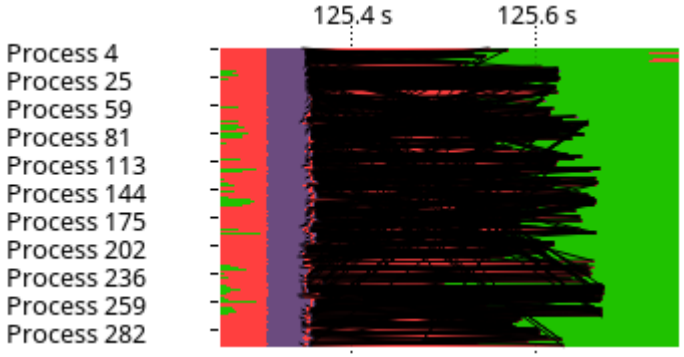
- Common tasks include detecting:
  - Incorrect communication,
  - Slow messages,
  - Load imbalances, and
  - Inefficient communication patterns

Introduction & Motivation

- Timeline visualizations [Lamport,1978] (Paraver [Pillet,1995], Intel Trace Analyzer [ITA,2016], Vampir [Brunst,2014])



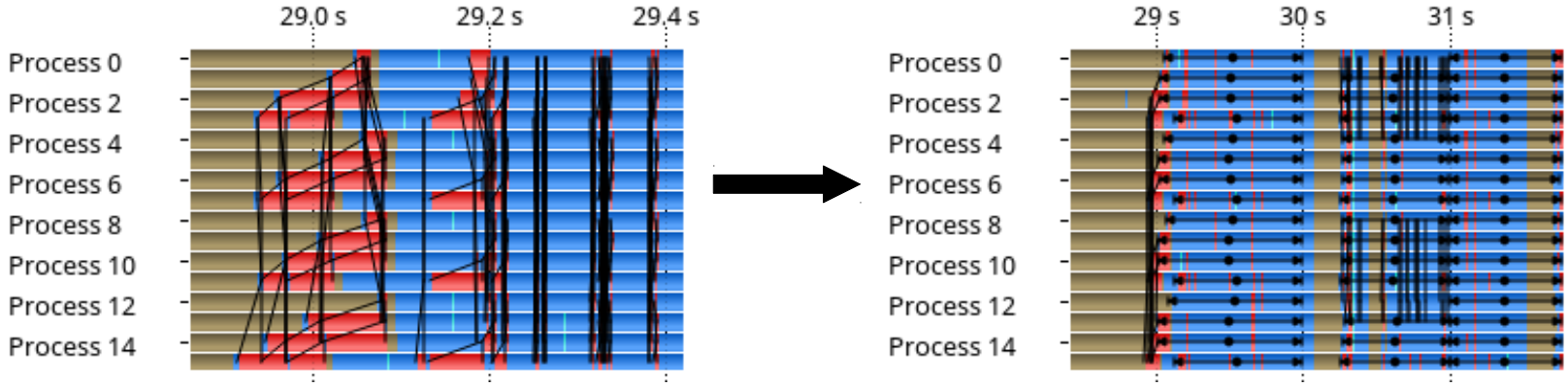
- Helpful message visualization at small scales



- But unfavorable visualization for many ranks

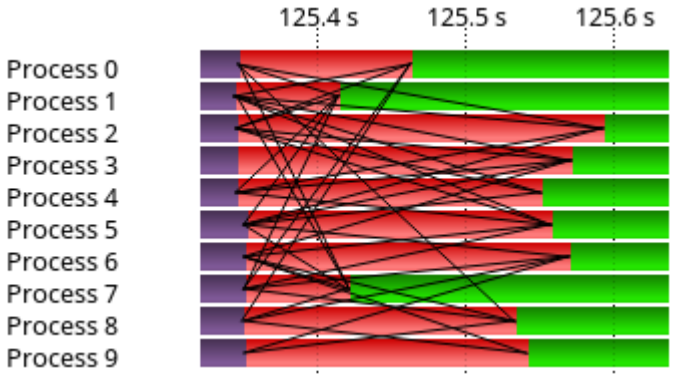
Introduction & Motivation

- Current solution in Vampir: Message Burst 
  - Start & end with the number of exchanged messages (varying circle size) encoded
  - Sender-oriented (target and duration are missing)



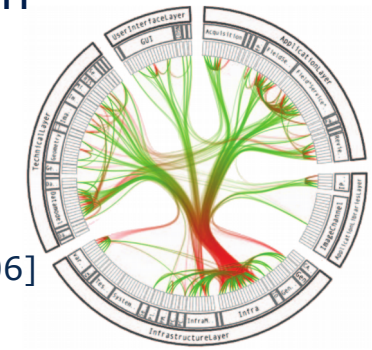
Introduction & Motivation

- No obvious patterns



- **Goal:**
  - Alleviate message clutter and information occlusion
  - Preserve interesting information
  - Highlight & amplify communication patterns

- Approach based on ideas from edge bundling [Holten,2006]



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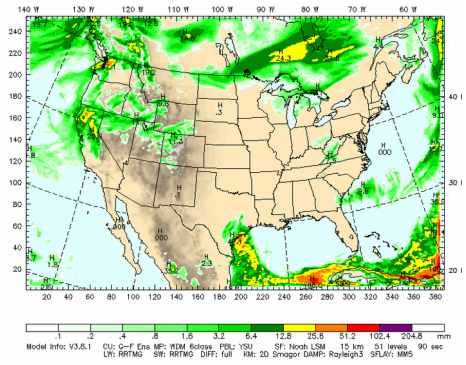
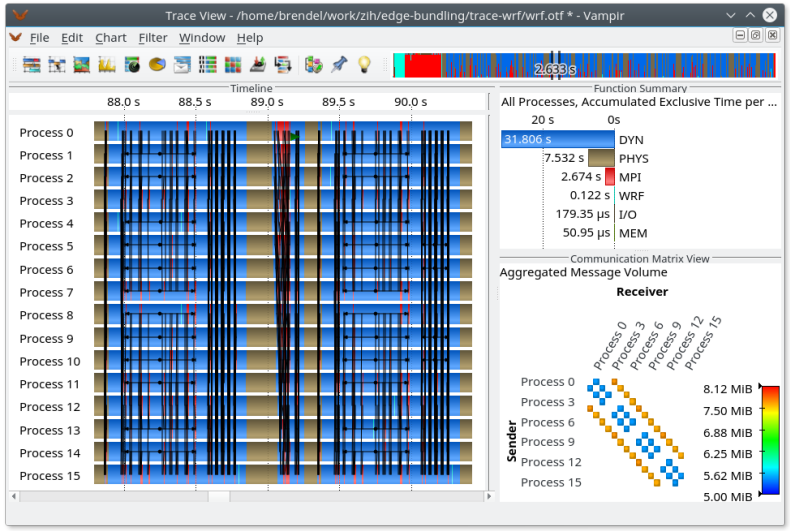
Test Cases

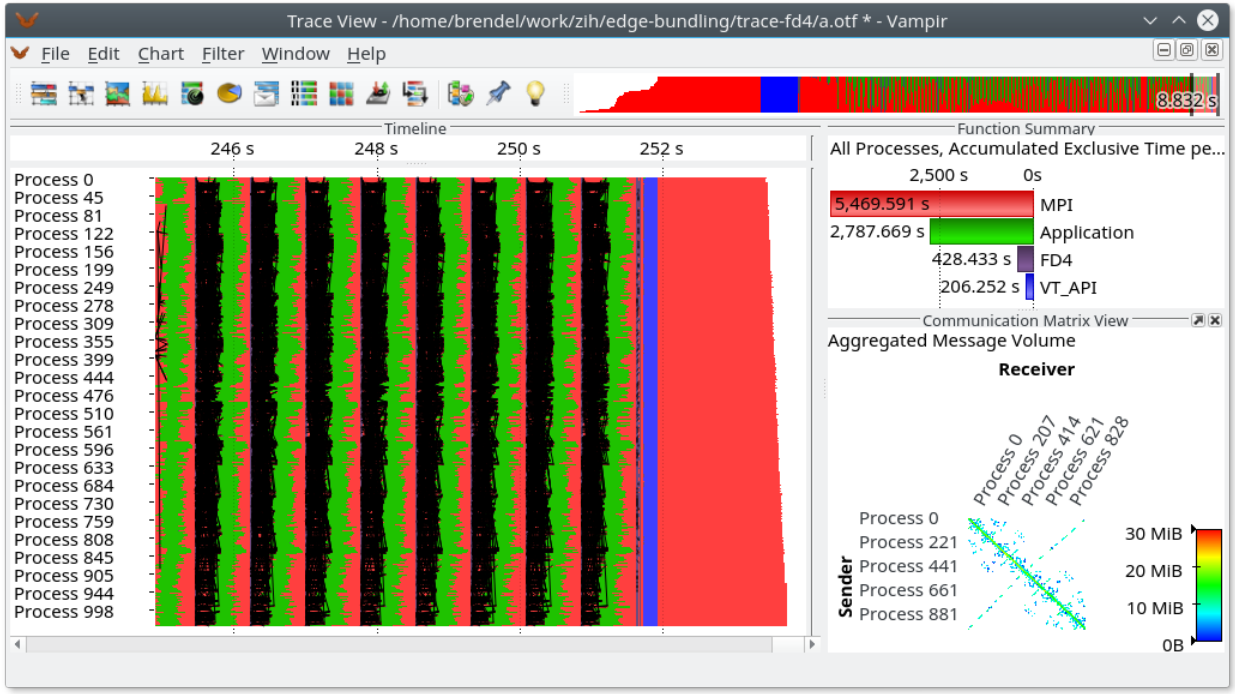
- Weather Research & Forecasting (WRF) [Michalakes,2001]
  - 16 processes
  - 4 minutes
  - 160k point-to-point messages
  - https://www.vampir.eu/public/files/tracefiles/Large.zip





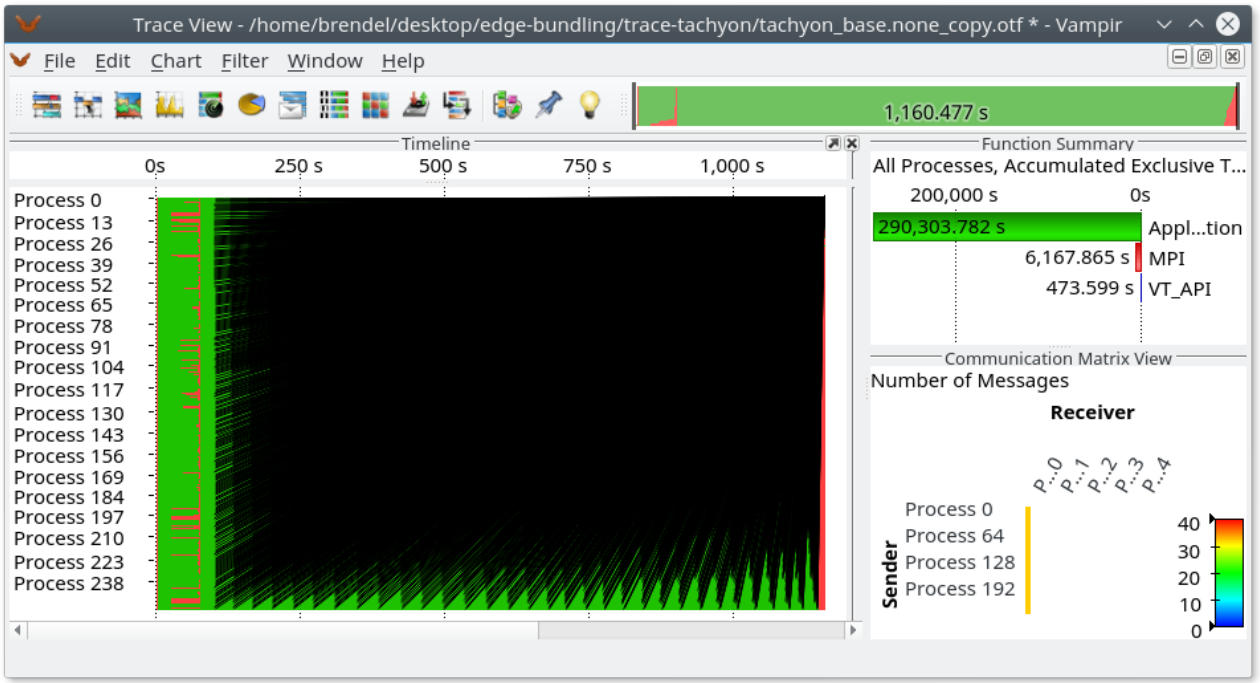
Test Cases

- FD4 [Lieber,2010]
  - 1,024 processes, 5 minutes, 2.2M messages



Test Cases

- Tachyon [SPEC,2016]
  - 256 processes, 20 minutes, 8,000 messages



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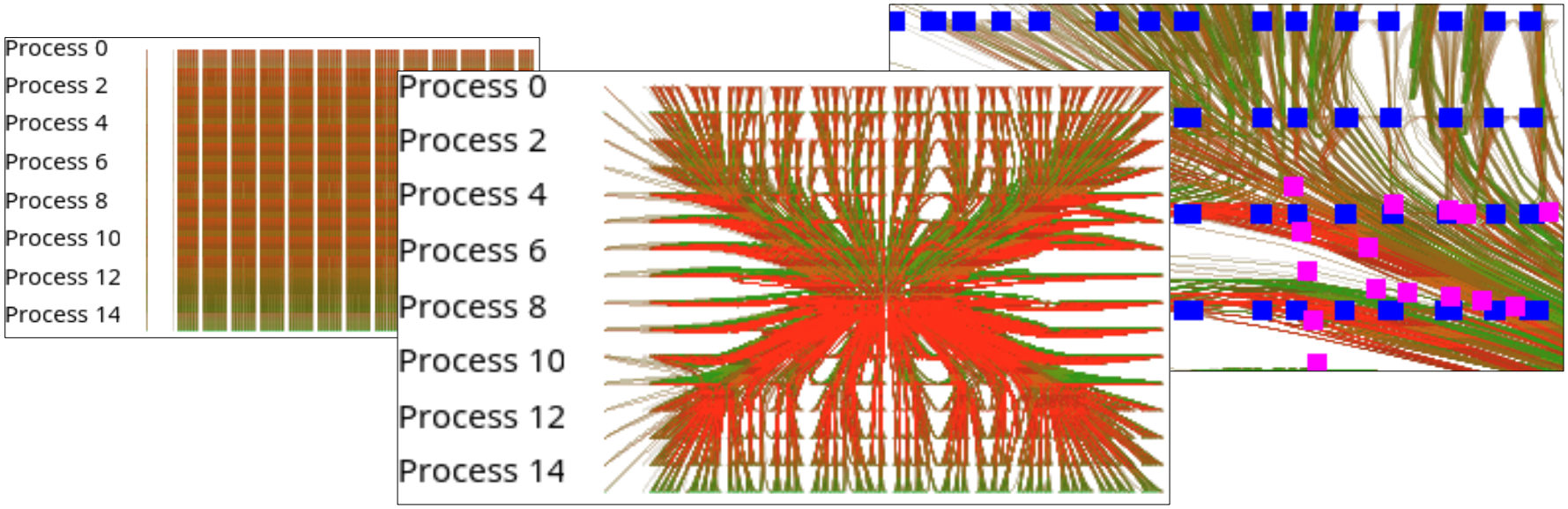
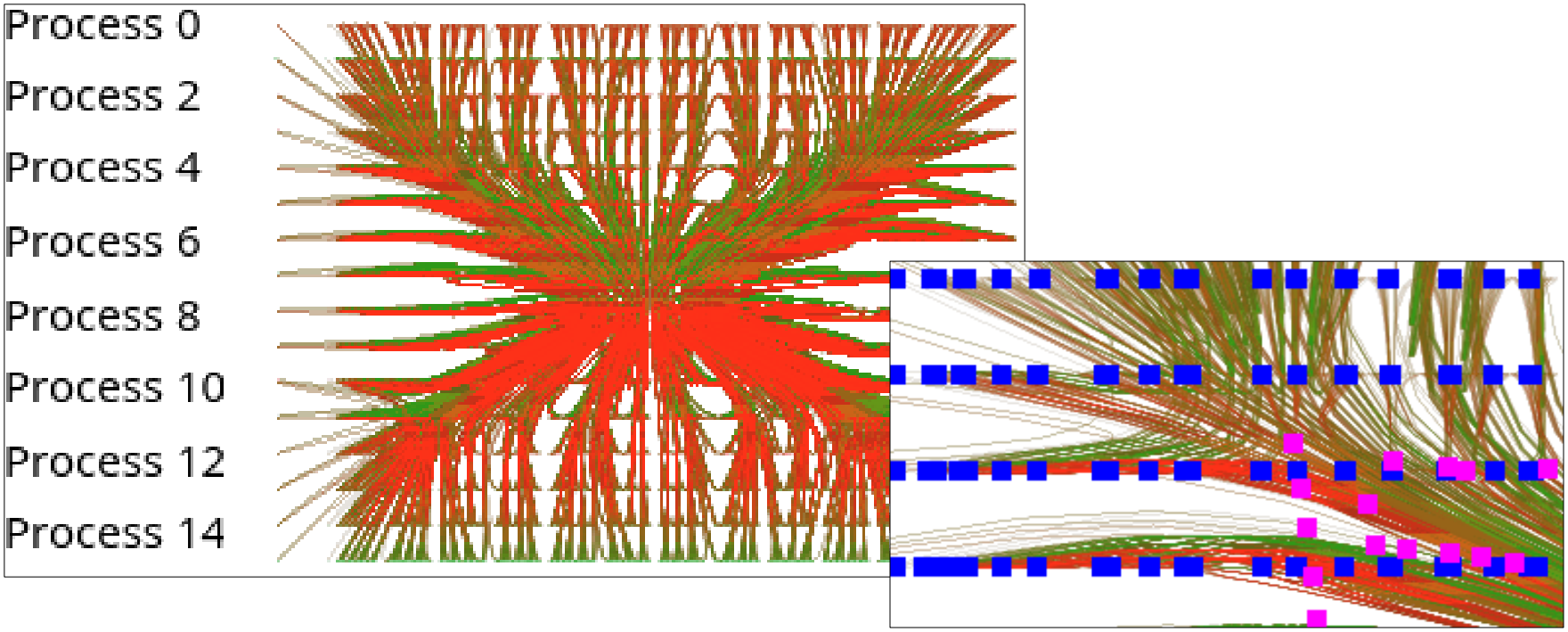
Edge Bundling > Time-based Vis.

- **Hierarchical** edge bundling [Holten,2006]
- B-Splines
- Send/receive event points + mean shift clustering = hierarchy
- Sender, Receiver (gradient)
- WRF



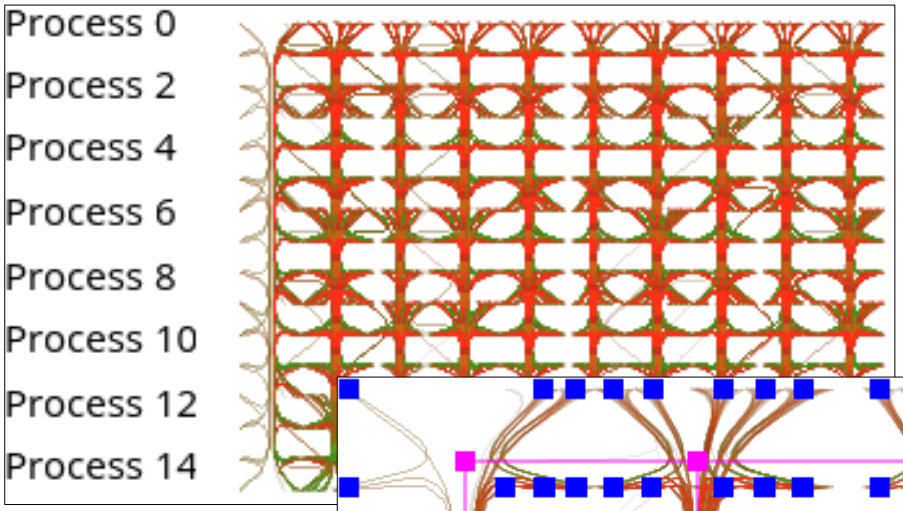
Edge Bundling > Time-based Vis.

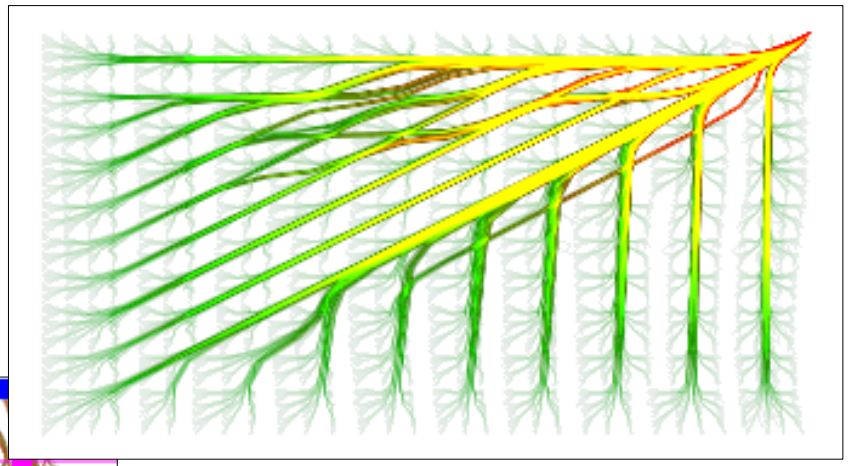
+ Occupies less space
– Extreme Bending towards the center of the diagram

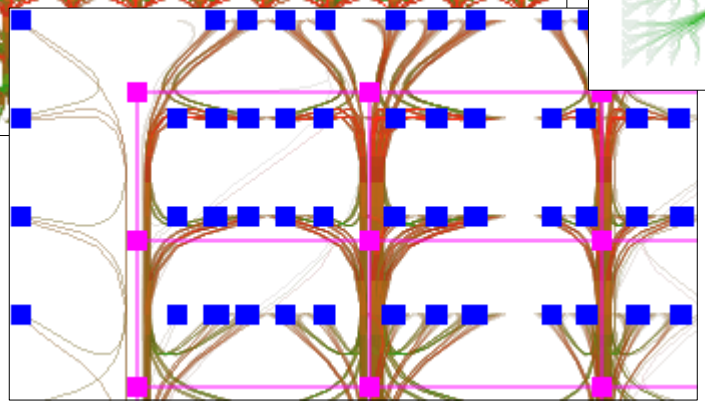


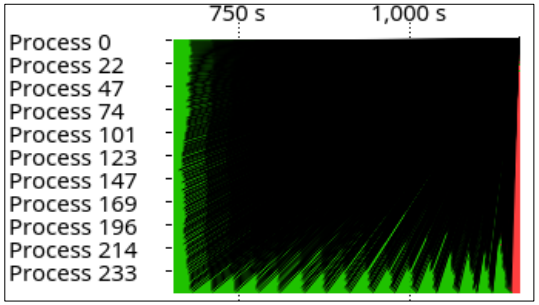
Edge Bundling > Time-based Vis.

- Grid-based Routing [Lambert,2010] + diagonals: WRF, Tachyon



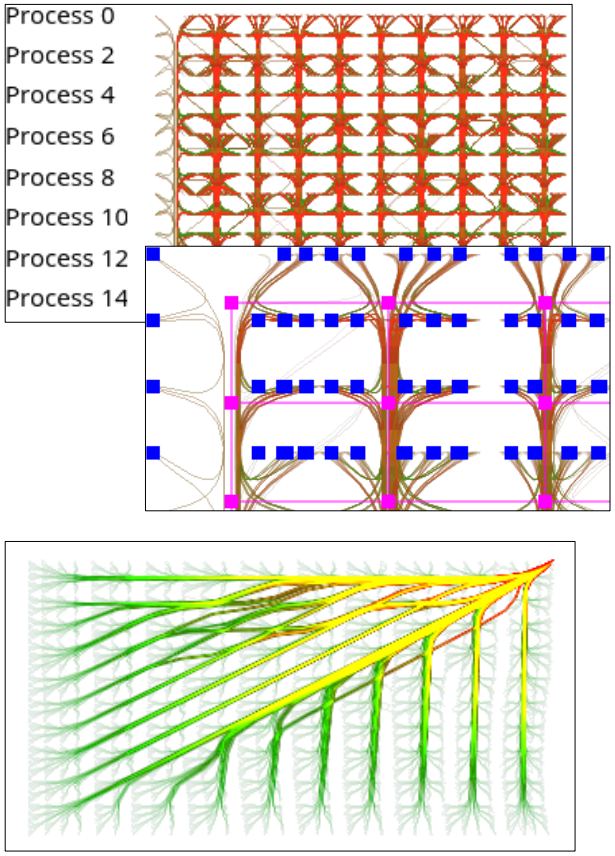






Edge Bundling > Time-based Vis.

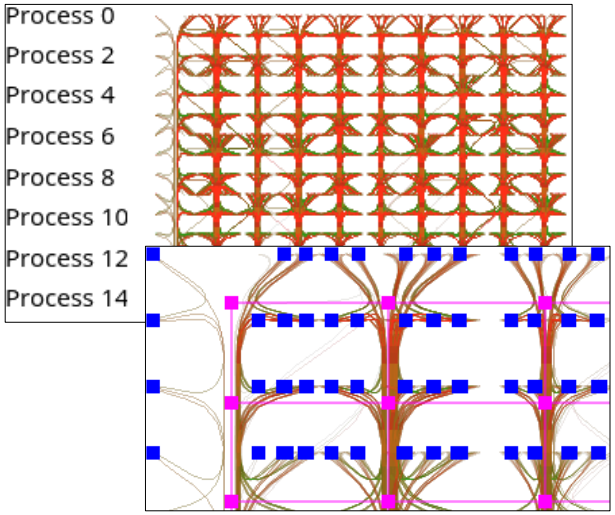
+ Less horizontal bending
+ Cleaned up representation
+ More intuitive
– Fixed position and size grid
– Still some horizontal bending

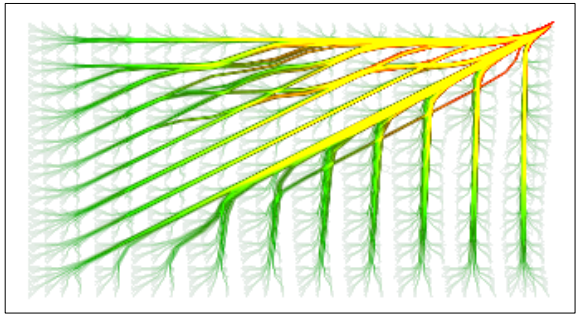


Edge Bundling > Time-based Vis.

- Parameter tuning is hard (line width, grid/hierarchy parameters, etc.)
  - Highly individual for each trace
  - But important for diagram quality
- Can be very slow
  - Invented for static image vis.
  - FD4 trace takes >20 min

➡ Try edge bundling for msg. summery





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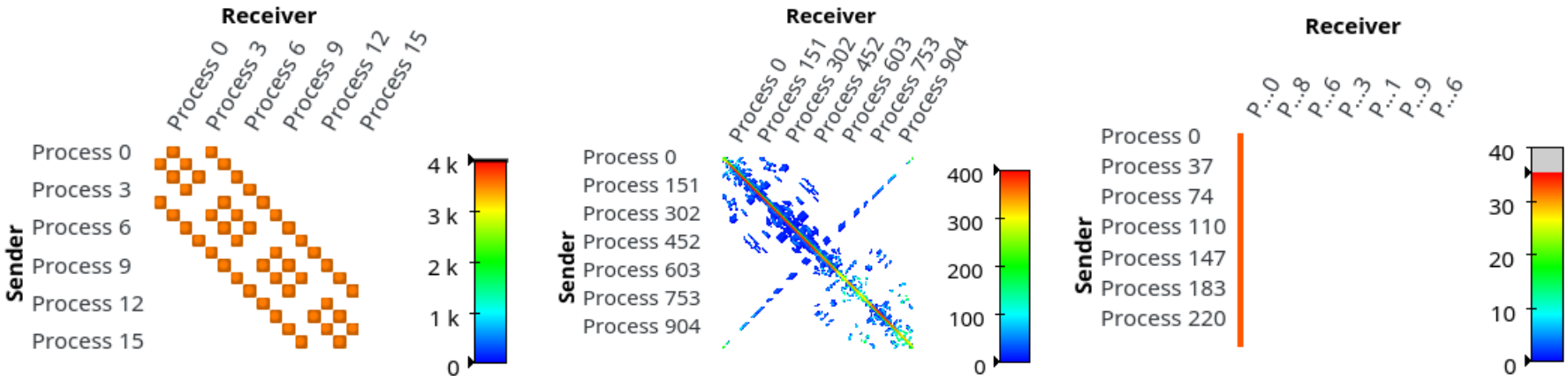
Edge Bundling > Summary Vis.

- Existing: *Communication Matrix:* WRF, FD4, Tachyon
  - Encode quantity into the points in color (here number of messages exchanged)

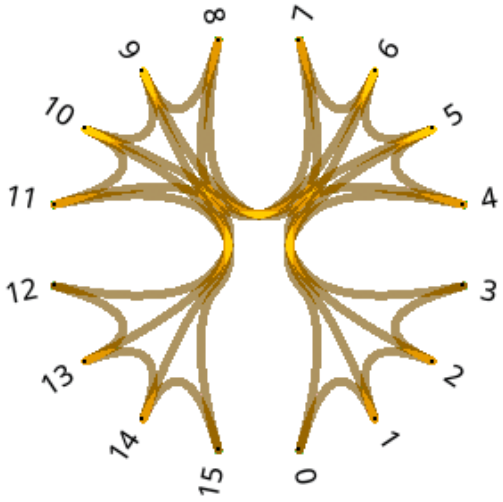


Edge Bundling > Summary Vis.

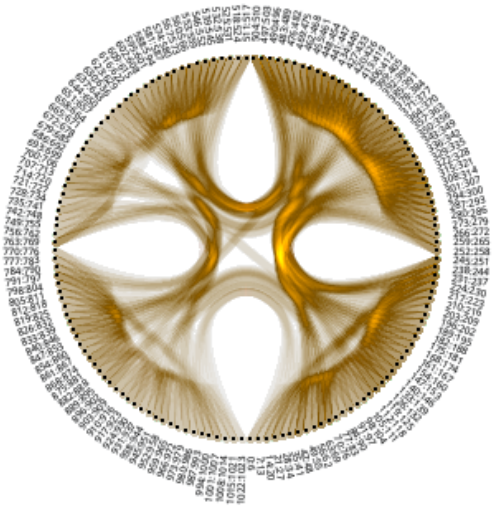
- Alternatively, use chord diagrams
  - Sender, Receiver

- Additivate color mixing: Not always helpful, but sometimes

WRF



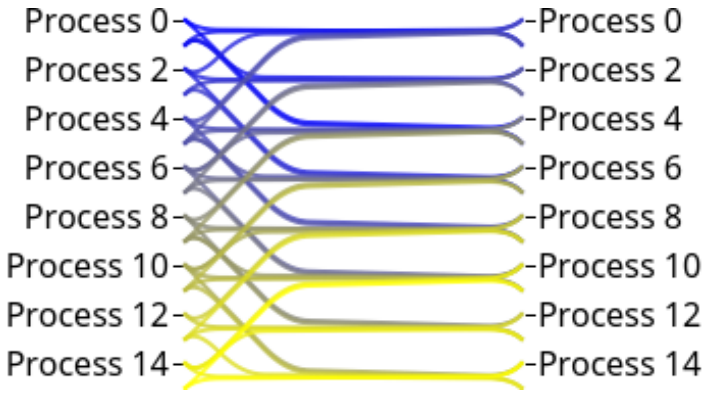
FD4

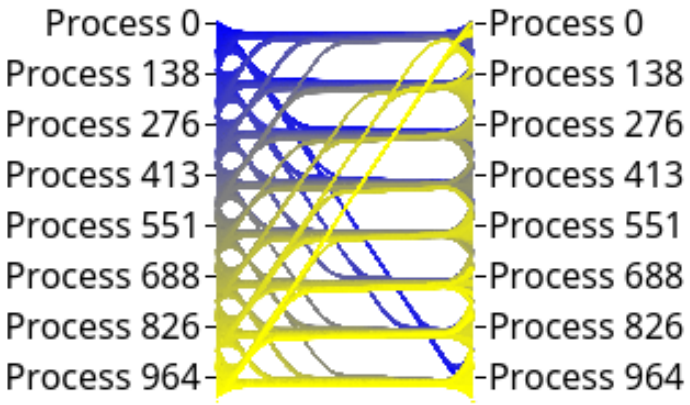


Tachyon

Edge Bundling > Summary Vis.

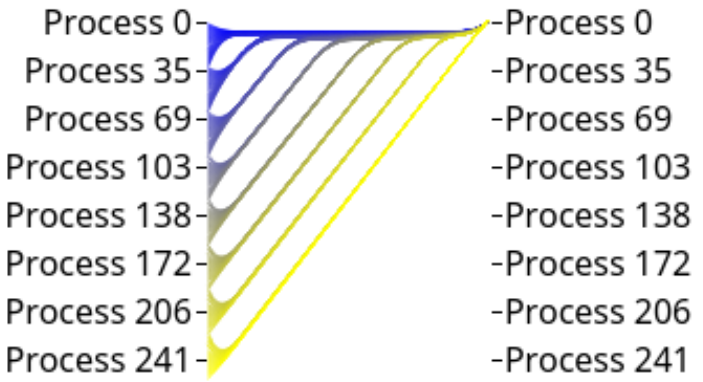
- *Sender/receiver diagram*
  - Sending process left, receiver right
  - Grid with diagonals
  - YX-Routing preferring diagonals
  - One color for each sender
- WRF: Near communication only
- FD4: Mostly near communication, some farther away receivers



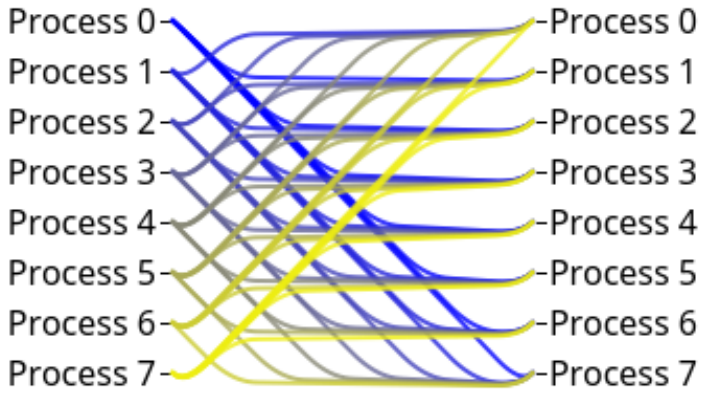


Edge Bundling > Summary Vis.

- Tachyon: all-to-one



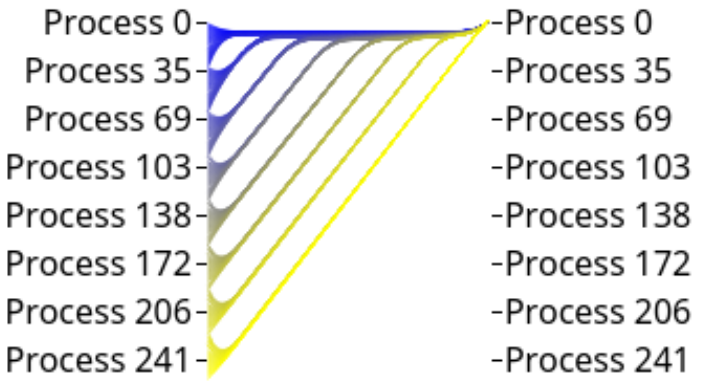
- LULESH [Karlin,2013]: all-to-all



Edge Bundling > Summary Vis.

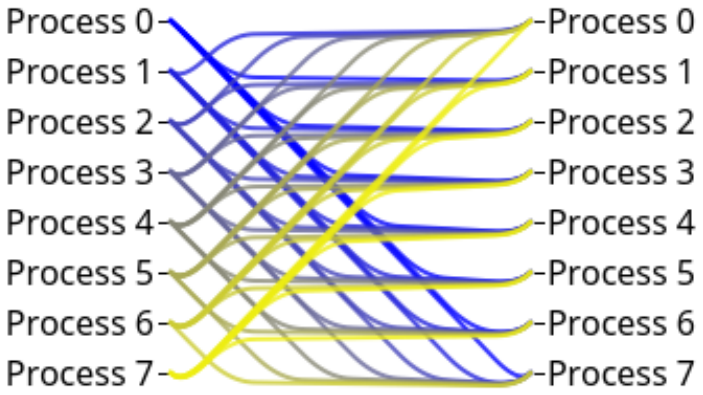
Advantages

- Some comm. patterns easily identifyable
- Good alternative to matrix view or chord diagrams



Disadvanages

- Parameter choice is challenging for also for summery vis.
- Implementation still rel. slow (FD4 appr. 30s)



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Conclusion

- Presented edge bundling for time-based and summary inter-process communication visualization

- Time-based Visualization:
  - Hierarchical produces unintuitive results
  - Grid-based approach better

- Introduced the sender/receiver diagram:
  - Simpler and faster
  - Improved ability to highlight communication patterns over other summary based visualizations

- Edge bundling proved challenging (parameter choice, tuning, ...)

Future Work

- Improve visual outcome of the sender/receiver diagram
- Encode quantities into edges
- Alternative ways to obtain control polygons

- Make edge bundling viable for time-based visualizations
  - Reduce message number via filtering
  - Flexible grid to improve image quality
  - Parallel implementation for runtime improvement

- Explore alternative edge bundling techniques, e.g. force-directed edge bundling [Holten,2009]

Slides and supplemental material:
https://github.com/hydroo/sc16-vpa-edge-bundling-for-visualizing-communication-behavior

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Tachyon with Hierarchical Edge Bundl.