Edge Bundling for Visualizing Communication Behavior

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VPA Workshop, Salt Lake City, 18th November, 2016
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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


- 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 \([\text{Holten, 2006}]\)
- 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.

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

- Additive color mixing: Not always helpful, but sometimes

![WRF](image1)
![FD4](image2)
![Tachyon](image3)
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
Advantages

• Some comm. patterns easily identifiable
• Good alternative to matrix view or chord diagrams

Disadvantages

• Parameter choice is challenging for also for summary 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]

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Tachyon with Hierarchical Edge Bundl.