# Scalability of Contextual Generalization Processing using Partitioning and Parallelization

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(processing large seamless datasets)

# Partitioning

# Handling large volume of data

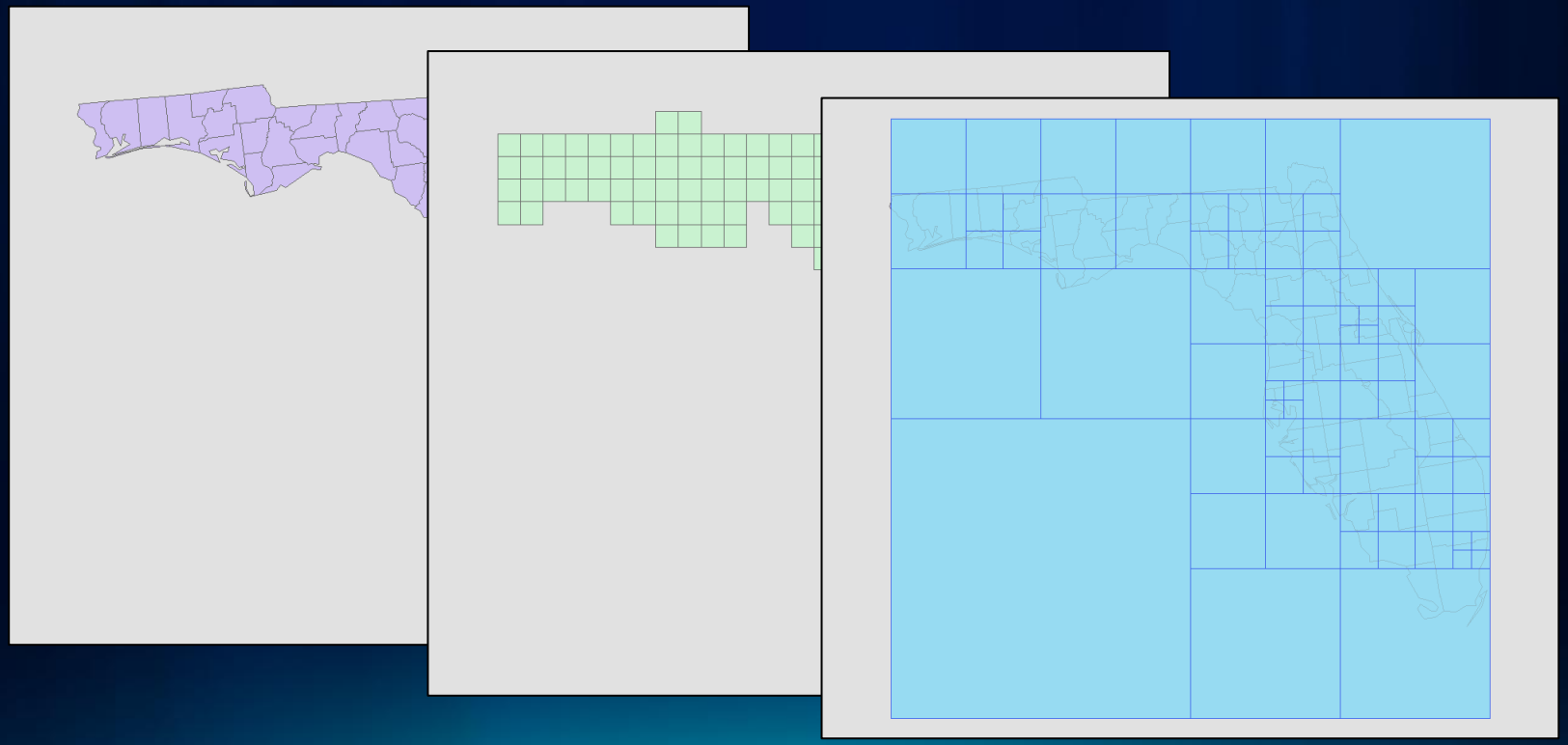
- At ArcGIS 10.0, contextual generalization tools are limited to a map sheet worth of data
  - 100,000 features
- Large seamless datasets are commonly available and need to be generalized
- Workflows to overcome those limits are complex and require additional database management steps. Sometimes the tools are simply not used.

# Handling large volume of data

- A natural approach is to consider partitioning the dataset spatial extent. Each partition is defined as a polygon feature and isolates a subset of data to process
- Partitions should:
  - Provide control over the volume of data
  - Be available for all tools used in the workflow
  - Not have any impact on the result

# Handling large volume of data

- We want partitions to be freely defined by the user



# Dealing with boundaries

- Two main goals
  - Provide seamless processing
  - Avoid post processing of boundaries
- Contextual tools
  - Cannot  arbitrarily stop at boundary
  - Need surrounding features, but up to what extent?

# Contextual tools

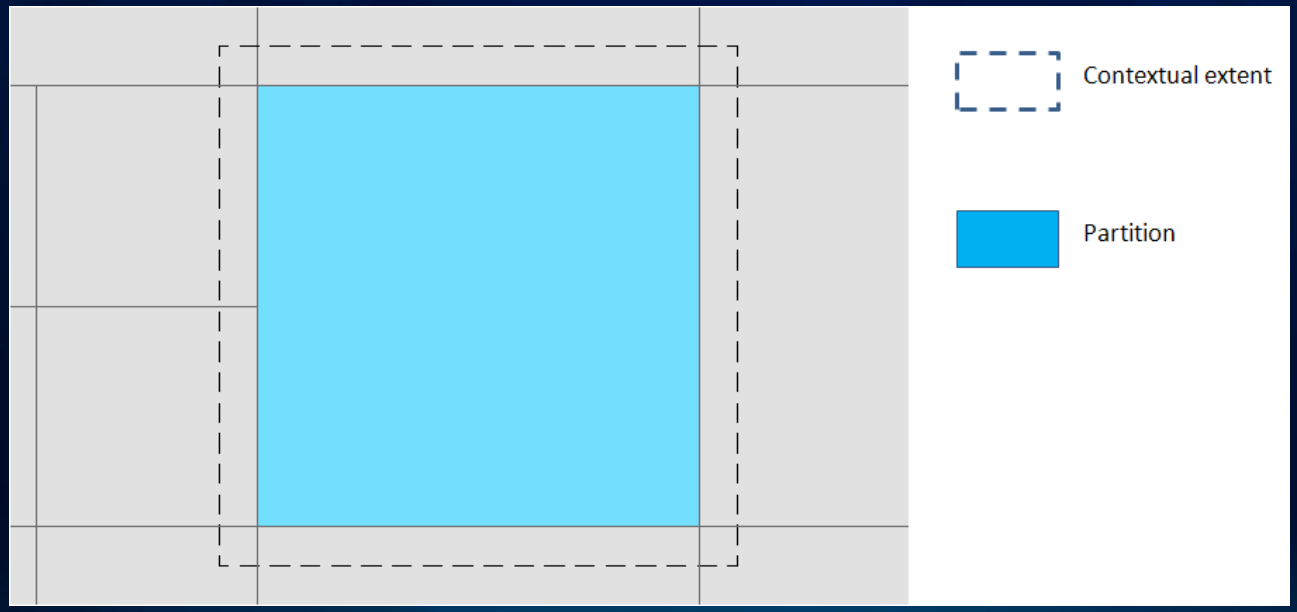
- Can we predict what extent around a partition has an impact on processing the content of the partition?

# Contextual tools

- For most of our tools, we can derive this maximum area of influence
  - Aggregation distance (aggregate polygons)
  - Merge distance (merge divided roads)
  - Minimum length (thin road network)
  - Symbol width (resolve road conflicts)
  - Etc.

# Adding a buffer

- Contextual aspect addressed by buffer
  - Load all features inside the buffer
  - Modify only features inside the partition



# Thin Road Network

# Thin Road Network

- Buffer value
  - Notion of how much a feature contributes to the network using its position inside multiple itineraries
  - Itineraries need to start at least from ‘Minimum Length’ outside the partition
  - Buffer = 1.5 x Minimum Length
- Features processed by one partition are considered “locked” for adjacent partitions

# Thin Road Network

- Entire streets network from California
  - 2,860,000 features
  - 157 partitions
  - 15,000 features overlapping boundaries
  - 75 visibility mismatch

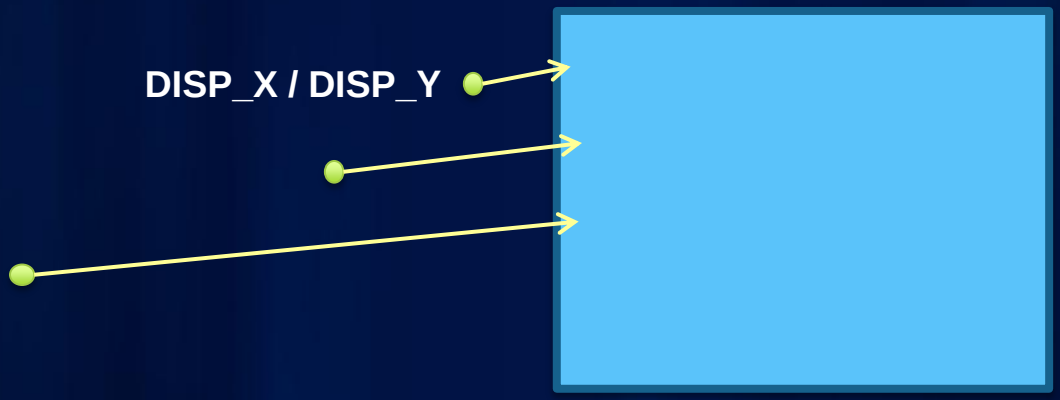
# Resolve Road Conflicts

# Resolve Road Conflicts

- Buffer
  - This tool resolves symbol overlaps
  - Distance is given by symbol width
  - Buffer = 10 x symbol width
- Modifications extend outside the partition

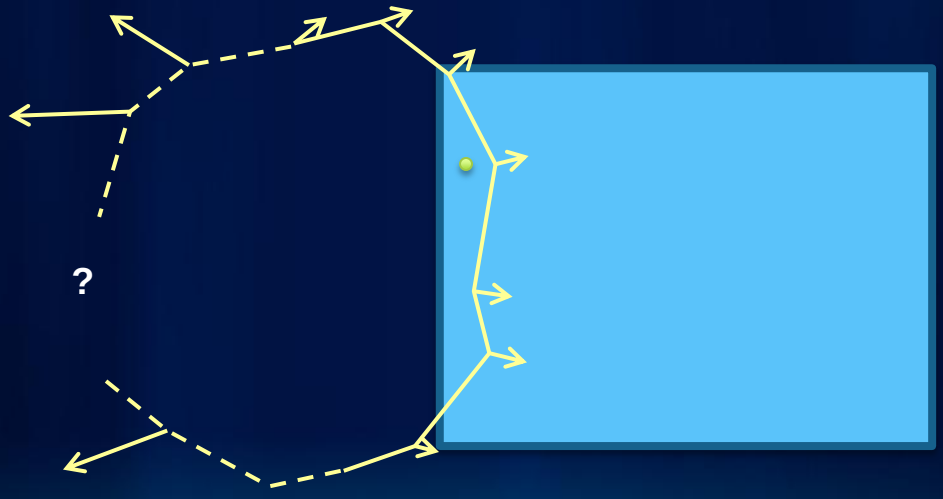
# Contextual tools that would not work

- Extent is not predictable
  - Distance of influence is supported by features
  - Case for the Propagate Displacement tool



# Contextual tools that would not work

- Features identify a larger structure
  - Lines forming a closed polygon
  - Case for the Propagate Displacement tool



# Controlling the buffer value

- Large buffer values
  - Impact the volume of data to load
  - Create additional neighbor partitions
- Worst case in our California test was +20% for the Thin Road Network tool (x10 scale jump)
- Favors a ladder approach (vs star)

# Parallel Processing

# Goals

- Prototype work
  - No plan to release this functionality
  - Experiment and learn
- Validate
  - This partitioning approach is suitable for parallel processing
  - No impact on workflow aspects
- Make our testing framework more efficient

# Database centric

- Concurrent access to data (input + partitions)
- The database synchronizes the work
  - Using locks on datasets
  - Processes wait for dataset availability
- Allows multiple clients
  - On same machine
  - On remote machines

# Prototype

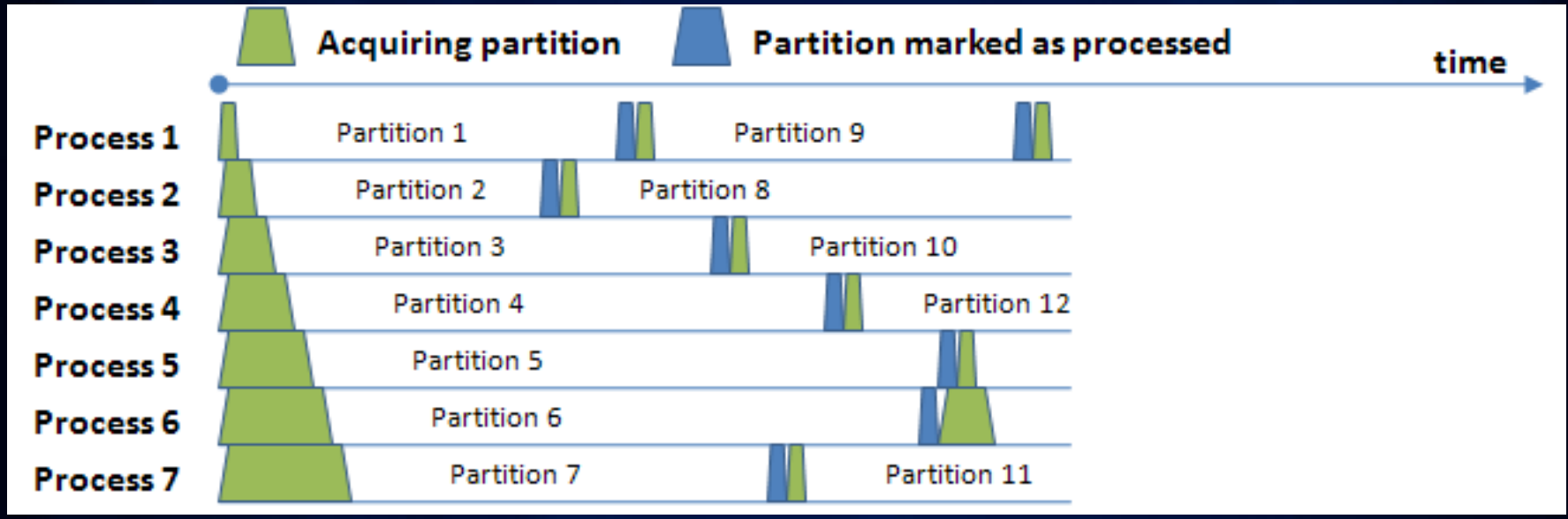
- Prototype uses a file geodatabase
- Setup requires
  - Defining a shared folder
  - Adding an exe into ArcGIS/bin
  - Enable parallel processing with some registry keys

# Transparent for the user

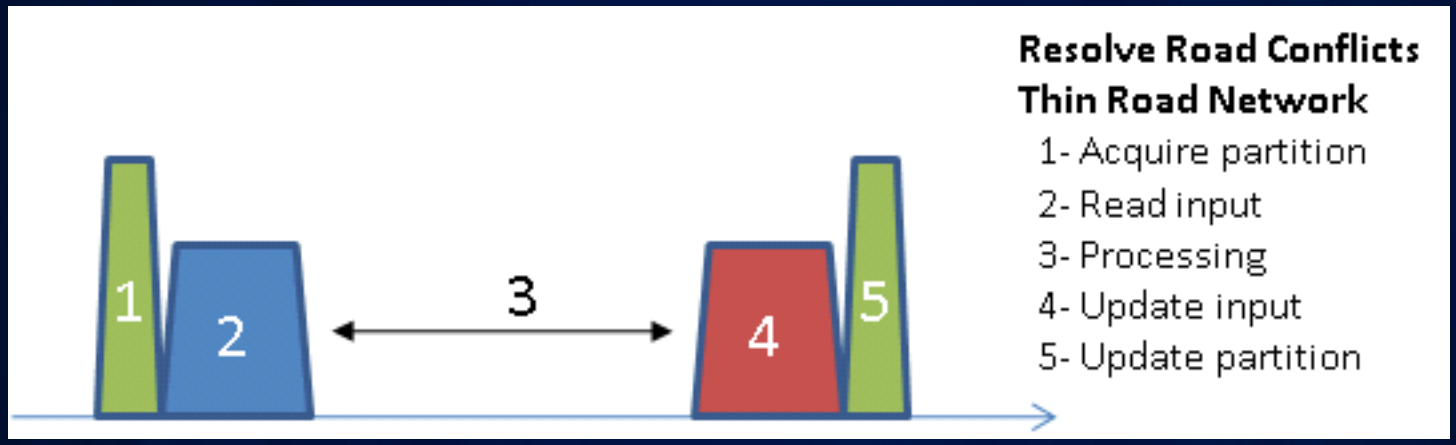
- User runs the geoprocessing tool as usual
  - A task file is added to the shared folder
  - Additional processes are started to work on the same task

# Processing partitions

- Locks to assign partitions to processes



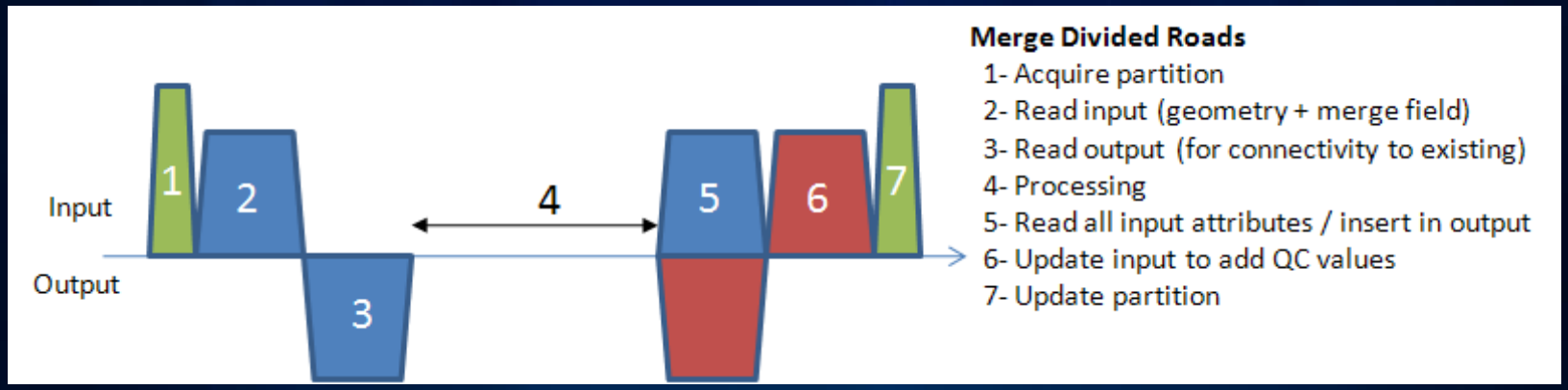
# Concurrent access to data




- Typical tool execution profile
  - In memory processing takes a lot more time than DB access
  - Makes DB locks acceptable

# Concurrent access to data

- Other tools have a more complex pattern
  - Deal with more datasets
  - Have a lower ratio of pure processing compared to processing + DB access

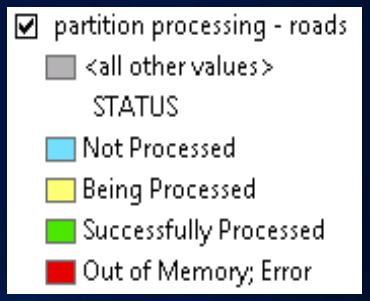


# Concurrent access to data

- Understanding those DB access patterns is important to decide how many parallel processes could work efficiently
- Potential improvements by creating output tables instead of qualifying the input
- Increasing the size of partitions improves the ratio

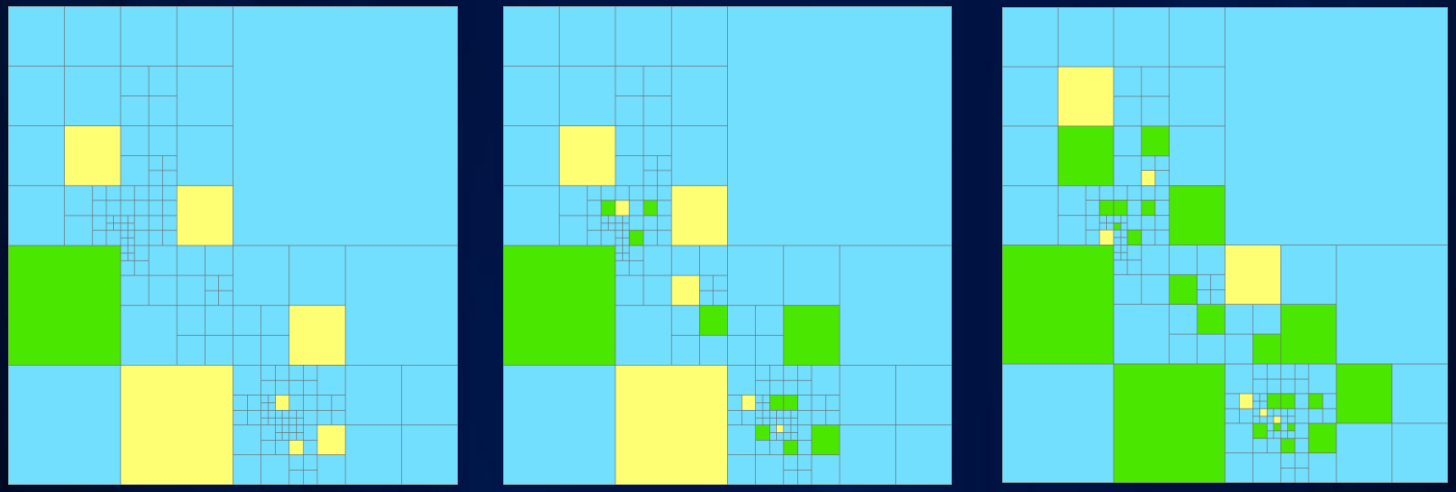
# Adjacent partitions

- Cannot process adjacent partitions simultaneously
  - Seamless database => Features will overlap multiple partitions
  - Some tools have to adapt to existing results (continue the work – *example of RRC*)
- Plan to prevent this to happen
  - Defined by the partition status



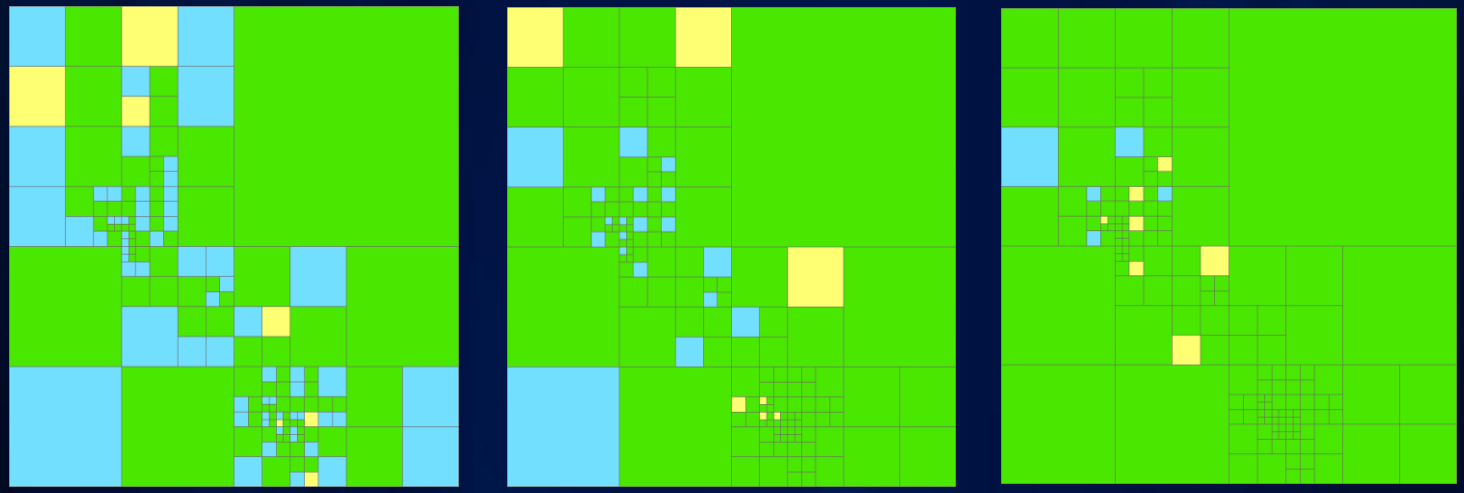
# Adjacent partitions

- **Process partitions with a lot of unprocessed neighbors first**



# Adjacent partitions

- Avoids neighbor conflicts when ending processing



# Some Results

- **Entire street network for the state of California**
  - **2,860,000 features / 157 partitions**
  - **50,000 features max per partitions**

| Tool | PC | With PP | Without PP | Ratio |
|---|---|---|---|---|
| Thin Road Network | 4 core<br>4 processes | 3h30min | 13h30min | **3.85** |
| Check Network Connectivity | 4 core<br>4 processes | 6min30s | 24min | **3.7** |
| Thin Road Network | 4 core HT<br>8 processes | 2h30min | 10h30min | **4.2** |
| Merge Divided Roads | 4 core HT<br>4 processes | 45min | 2h45min | **3.7** |
| Resolve Road Conflicts | 4 core HT<br>8 processes | 3h35min | 12h30min | **3.5** |

# Future work

- Make more tools work with partitions
- Continue improving results quality
- Adapt prototype to new pieces of technology
  - Cloud computing
  - Geoprocessing services