Model Checking MST Construction Algorithm

Haneen Dabain

Department of Computer Science and Engineering
York University

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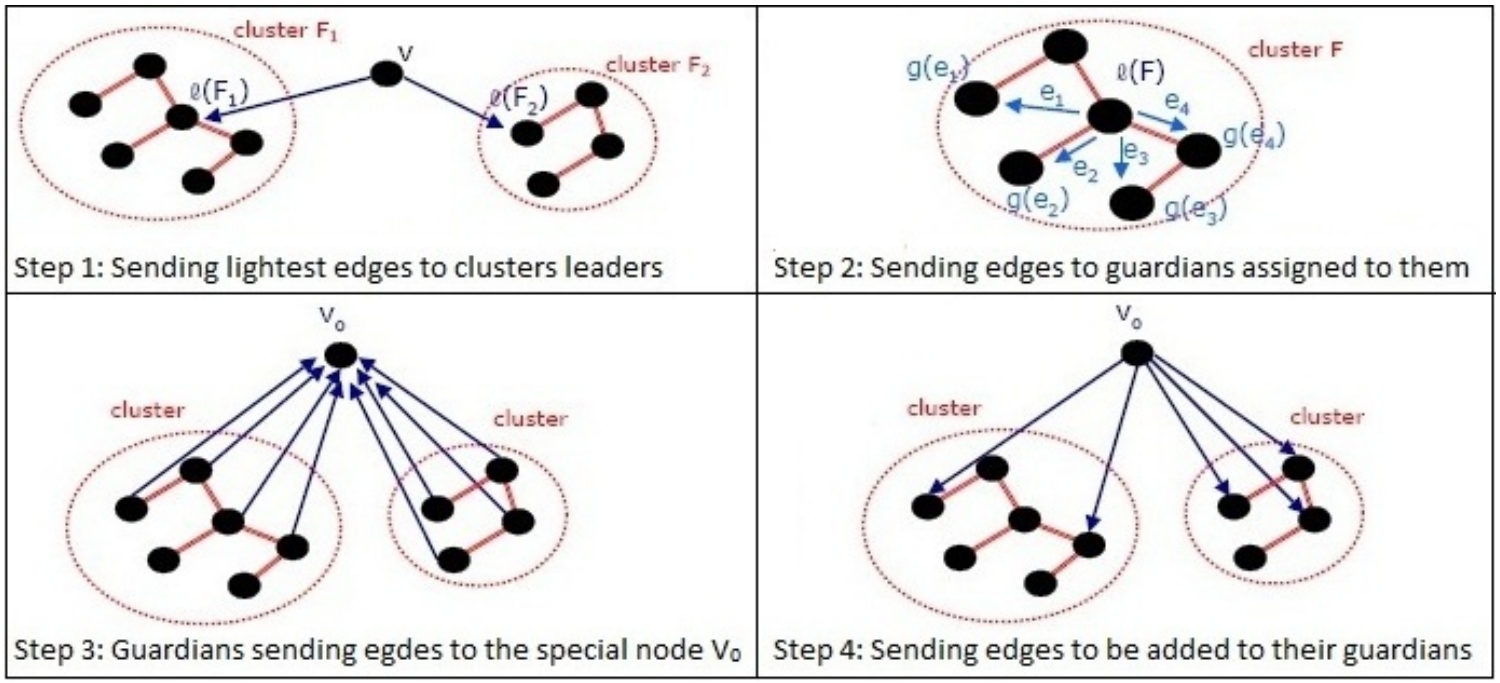
The Algorithm



- V_0: A special node in the graph, e.g., the node with the smallest ID in the graph.
- $l(F)$: A leader of cluster F, e.g. the node with the smallest ID in the cluster.
- $g(e)$: A guardian node assigned to each minimum weight edge e.

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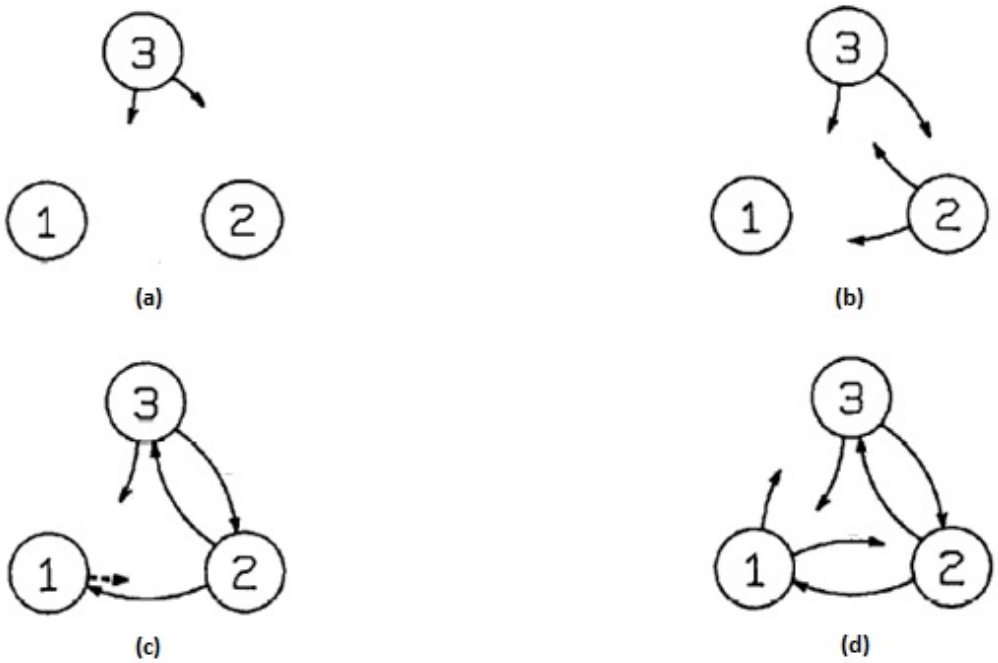
The Model



- Nodes are considered as processes which are wired together using One2OneChannels
- Channels communication is synchronous.

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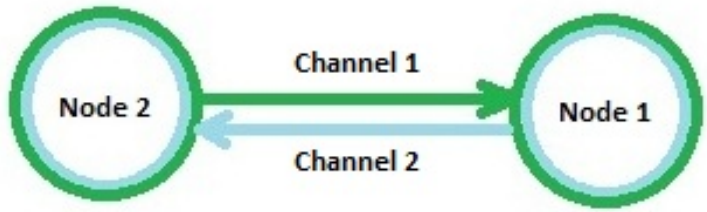
Dead Lock

- Two processes executing a receive (read) command and waiting the other process to send (write)
- Both processes will be locked
- A single process can either send or receive but not both
- Each node has two processes running in parallel



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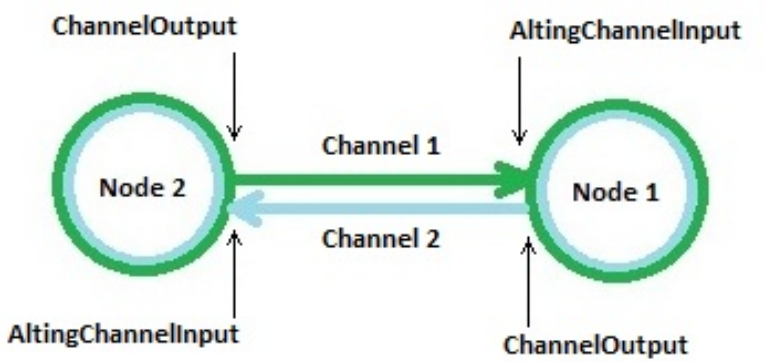
Communication Channels

```
final One2OneChannel[] inputOutputChannels =
Channel.createOne2One(totalNumberOfChannel);
```



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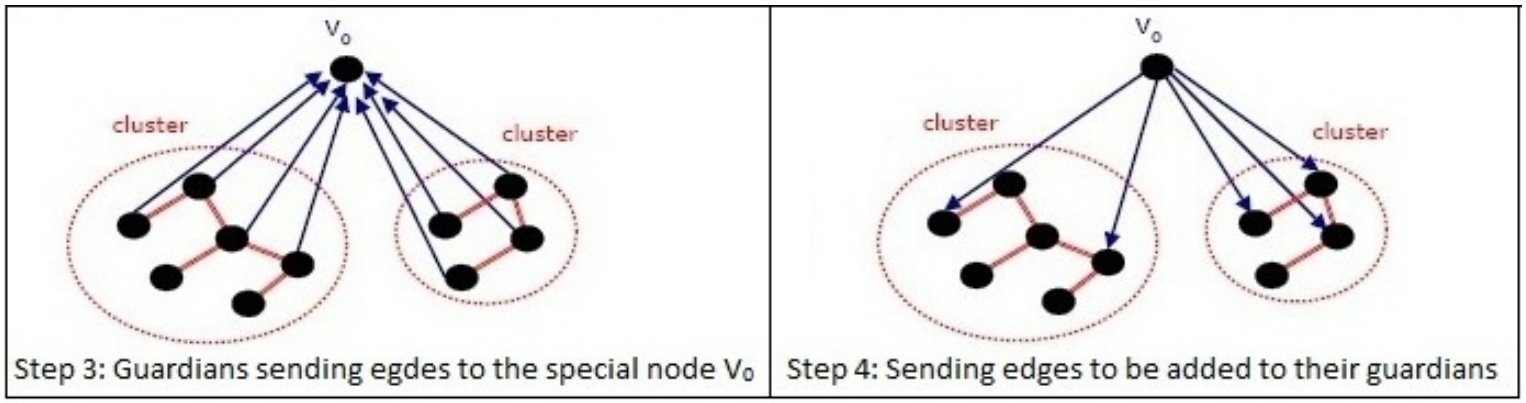
Parallelism




```
Parallel par = new Parallel;
CSProcess[] activeProcesses = new CSProcess[] {
        new Parallel(ActiveSendingProcs),
        new Parallel(ActiveReceivingProcs)}
par = new Parallel(activeProcesses);
par.run ();
par.releaseAllThreads();
```

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Testing - Listeners

- No shared objects were used. Therefore, we do not need to check the implementation for Data Races
- Deadlocks.
- Unhandled Exception.

Testing - Assertion

- MST algorithm solves the problem in $O(\log \log n)$ communication rounds.
- Algorithm woks in phases.
- Clusters have to grow faster by merging clusters.
- $\beta_{k+1} \geq \beta_k(\beta_k + 1)$, where β_k denotes the minimum cluster size in phase k.

```
assert(beta >= oldBeta * (oldBeta + 1));
```

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JCSP Library

```
Parallel par = new Parallel(processArray);
par.run ();

at org.jcsp.lang.Barrier.sync(Barrier.java:458)
at org.jcsp.lang.ParThread.run(ParThread.java:129)
================================================== results
error #1: gov.nasa.jpf.jvm.NotDeadlockedProperty "deadlock encountered:
thread index=0,name=main,s..."
================================================== statistics
elapsed time: 0:00:01
states: new=121, visited=0, backtracked=7, end=8
max memory: 7MB
loaded code: classes=118, methods=1514
================================================== search finished
```

JCSP Library

```
Parallel par = new Parallel(processArray);
par.run ();
par.releaseAllThreads();
```

Our Implementation - Trial 1 (Entire Algorithm)

- 2 nodes
- One edge
- 4 threads

```
Parallel par;
CSProcess[] activeProcesses = new CSProcess[] {
        new Parallel(ActiveSendingProcs),
        new Parallel(ActiveReceivingProcs)}
par = new Parallel(activeProcesses);
par.run ();
par.releaseAllThreads();
```

Our Implementation - Trial 1 (Entire Algorithm)

at org.jcsp.lang.Barrier.sync(Barrier.java:458)
at org.jcsp.lang.ParThread.run(ParThread.java:129)

========== results
error #1: gov.nasa.jpf.jvm.NotDeadlockedProperty "deadlock encountered: thread index=0,name=main,s..."

Our Implementation - Trial 1 (Entire Algorithm)

- CSProcess[] activeProcesses = new CSProcess[] {
  new Parallel(ActiveSendingProcs),
  new Parallel(ActiveReceivingProcs)}
- CSProcess[] activeProcesses =
  getNodeProcessesArray(allSendProc,currentRecProc);

```
par = new Parallel(activeProcesses);
par.run ();
par.releaseAllThreads();
```

Our Implementation - Trial 2 (Entire Algorithm)

```
[SEVERE] JPF out of memory
====================================== results
no errors detected
====================================== statistics
elapsed time: 8:51:06
states: new=38636247, visited=94670414, backtracked=133306104, end=420036
search: maxDepth=778, constraints=0
choice generators: thread=38472906, data=0
heap: gc=158521261, new=14311429, free=239043276
instructions: 737303224
max memory: 888MB
loaded code: classes=143, methods=1973
====================================== search finished
```

Our Implementation - Trial 3 (First Step)

```
no errors detected
========================================== statistics
elapsed time: 0:17:50
states: new=1370626, visited=3782731, backtracked=5153356, end=130
search: maxDepth=260, constraints=0
choice generators: thread=1370499, data=0
heap: gc=5166044, new=1598525, free=573435
instructions: 110903870
max memory: 93MB
loaded code: classes=140, methods=1918
========================================== search finished
```

Our Implementation - Trial 4 (Second Step)

```
no errors detected
====================================================== statistics
elapsed time: 0:46:12
states: new=1298159, visited=3571225, backtracked=4869383, end=519
search: maxDepth=311, constraints=0
choice generators: thread=1298032, data=0
heap: gc=4887670, new=1528776, free=608617
instructions: 105324508
max memory: 49MB
loaded code: classes=136, methods=1866
====================================================== search finished
```

Our Implementation - Trial 5 (Third Step)

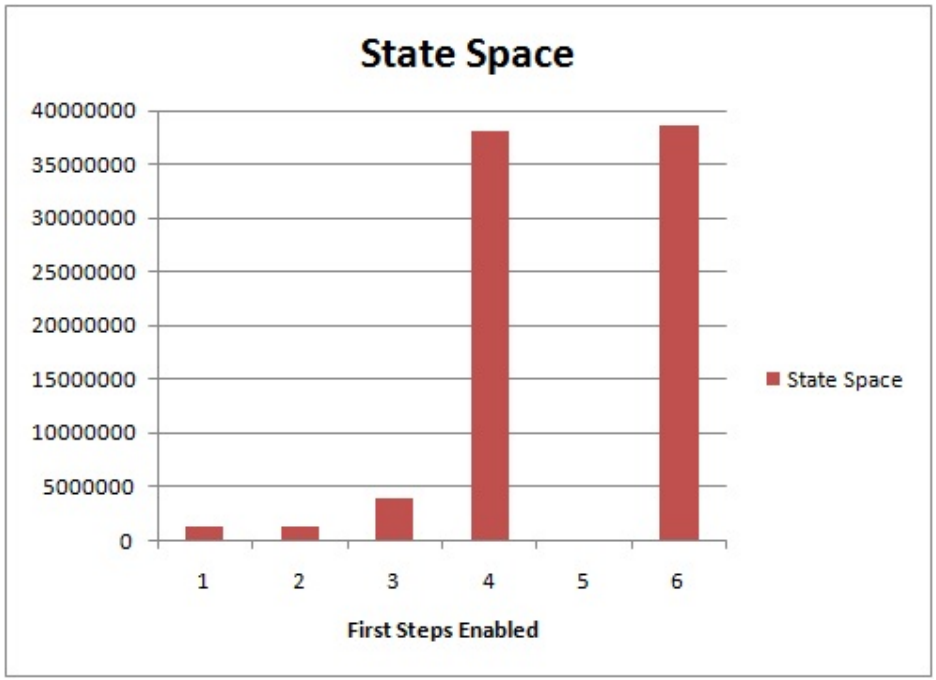
```
no errors detected
========================================== statistics
elapsed time: 0:49:30
states: new=3990376, visited=8583713, backtracked=12574088, end=14033
search: maxDepth=484, constraints=0
choice generators: thread=3983486, data=0
heap: gc=14013309, new=7736566, free=20215534
instructions: 621762099
max memory: 143MB
loaded code: classes=142, methods=1944
========================================== search finished
```

Our Implementation - Trial 6 (Fourth Step)

```
no errors detected
====================================================== statistics
elapsed time: 7:56:43
states: new=38076153, visited=82309538, backtracked=120385690, end=528700
search: maxDepth=609, constraints=0
choice generators: thread=37991259, data=0
heap: gc=140860290, new=18254546, free=213635583
instructions: 217063450
max memory: 880MB
loaded code: classes=142, methods=1944
====================================================== search finished
```

Summary

- Graph of size 2.
- Over than 38 million states, no error detected
- First 5 steps, no error detected
- Could not check the assertion



Questions?