# Non-slicing Floorplanning-based Crosstalk Reduction on Gridless Track Assignment for a Gridless routing System with Fast Pseudo-Tile Extraction

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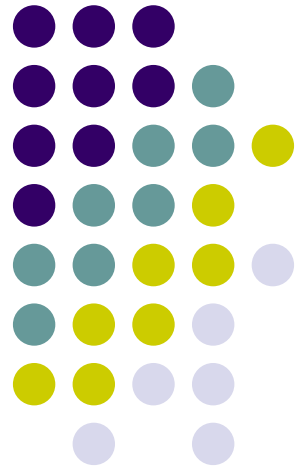
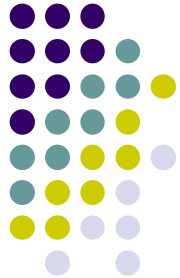


# Outline

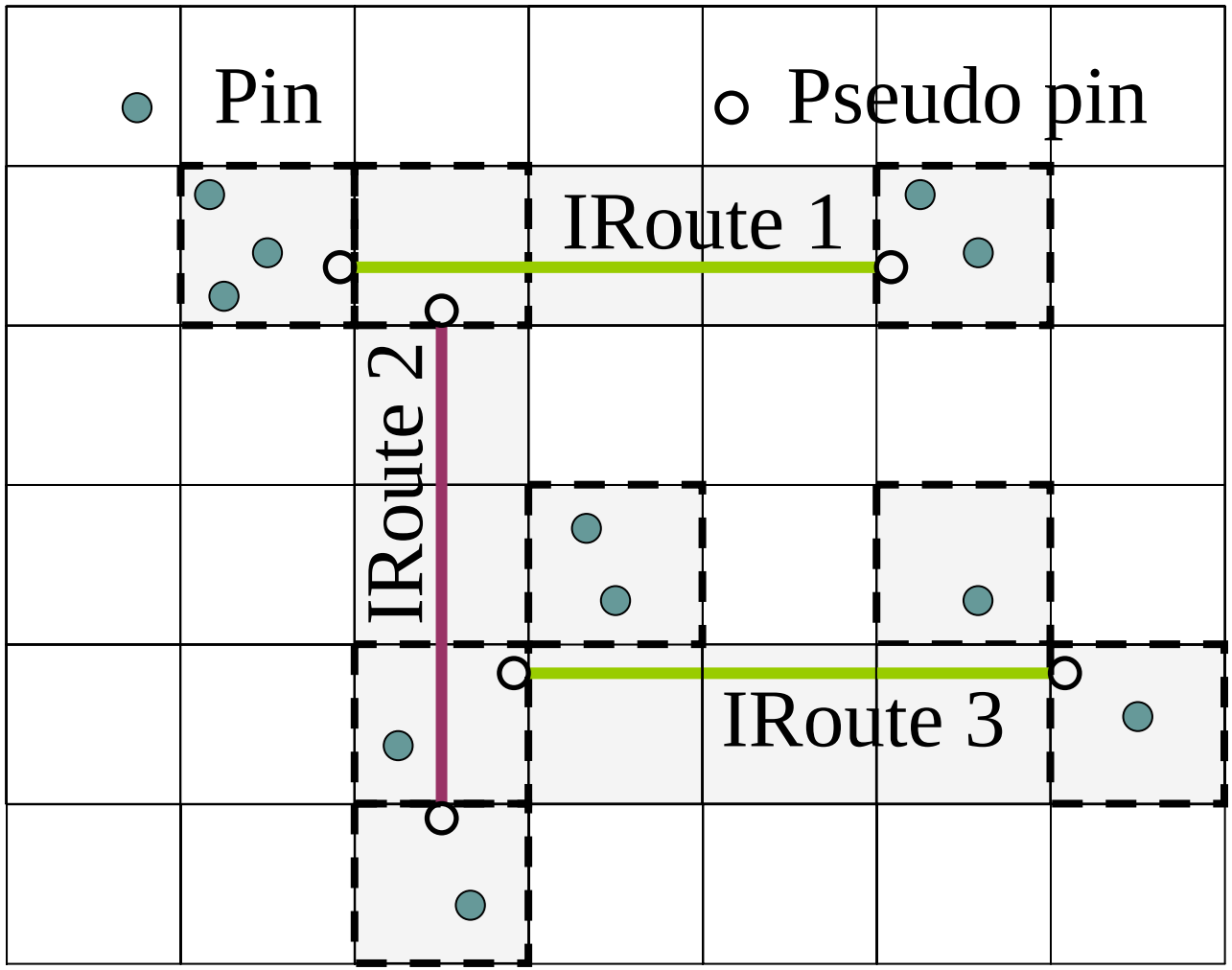
- Introduction
- Crosstalk-Driven GTA
- Detailed Routing
- Experimental Results
- Conclusion

# Why Gridless and Crosstalk-Driven Router ?

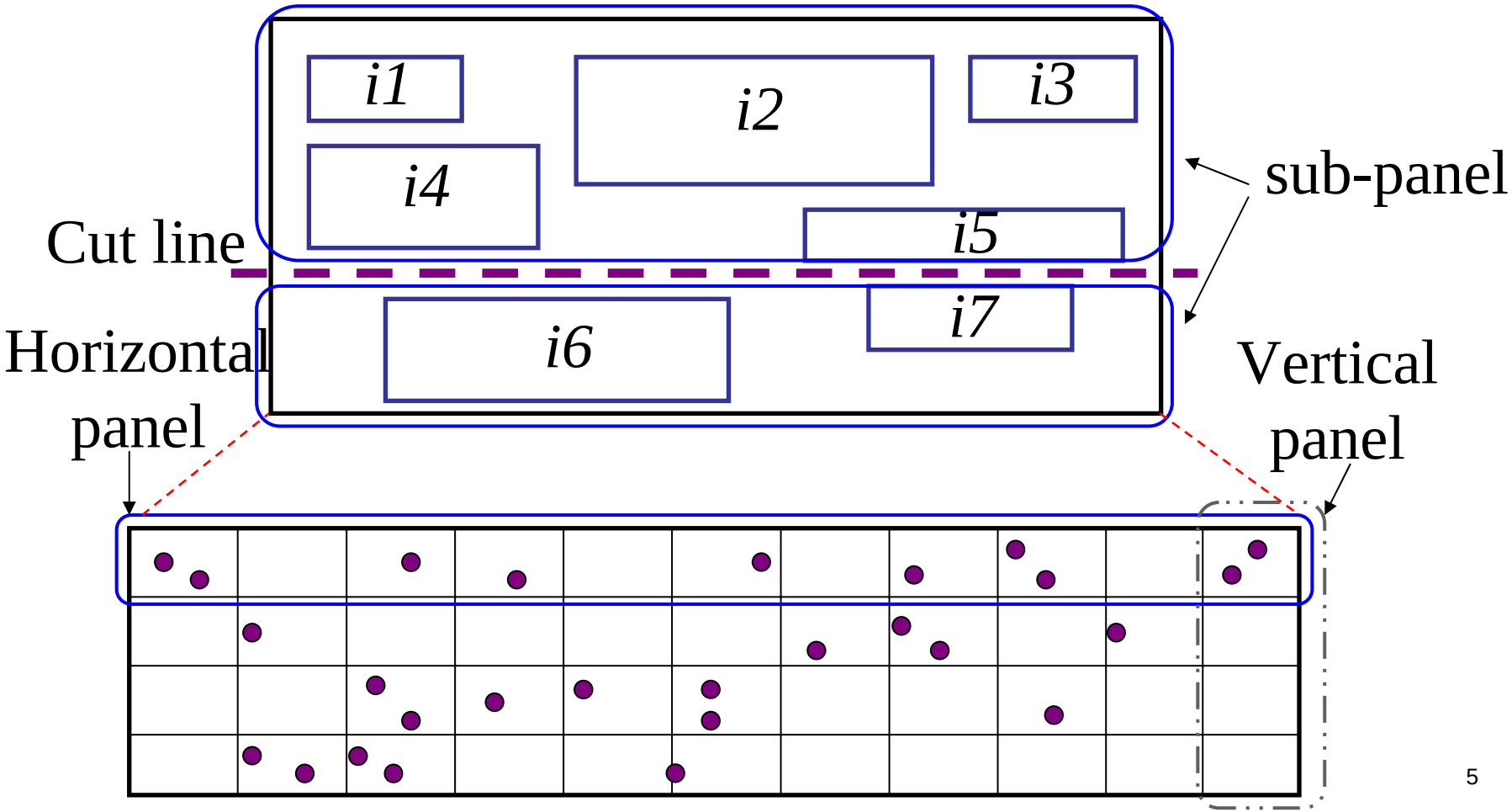


- Crosstalk induced by adjacent wires increases the coupling capacitance and delay of the wires.
- In modern designs, variable-width and variable-space routing is commonly used for the purpose of crosstalk and delay optimization
- Gridless routers are more flexible for variable-rule routing than grid-based routers

# Preliminaries



# Preliminaries

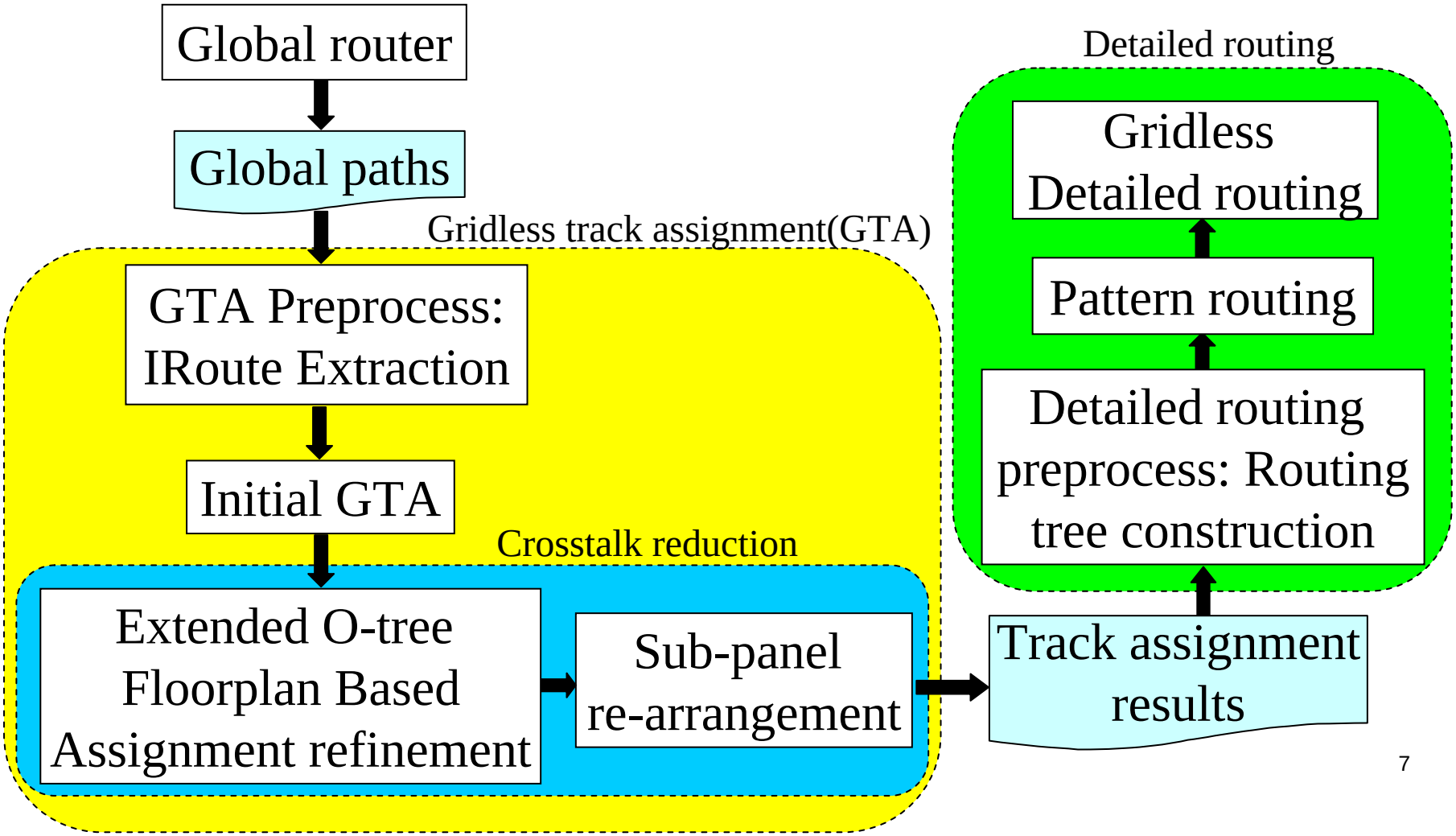


# Preliminaries

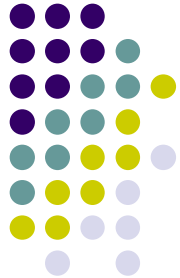
- Crosstalk Model
- f is switching factor
- l is coupling length
- d is distance

$$C_c(i, j) = \alpha \cdot f_{i,j} \cdot \frac{l_{i,j}}{d_{i,j}^{\beta}}$$

# Routing Flow



# Contributions of this work



- This work develops a complete crosstalk-driven three-stage gridless routing system.
  - A congestion-driven global router
  - A crosstalk-driven gridless TA (GTA)
  - Enhanced NEMO with fast PMT extraction for detailed router.

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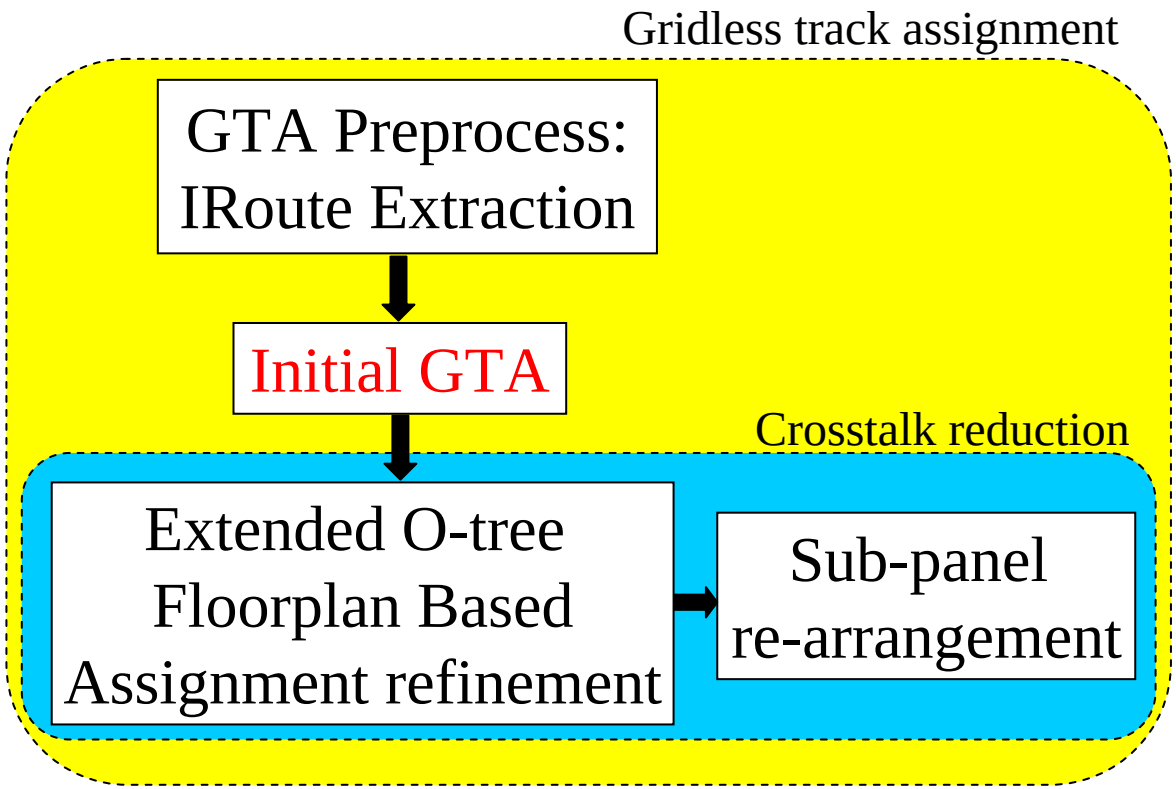
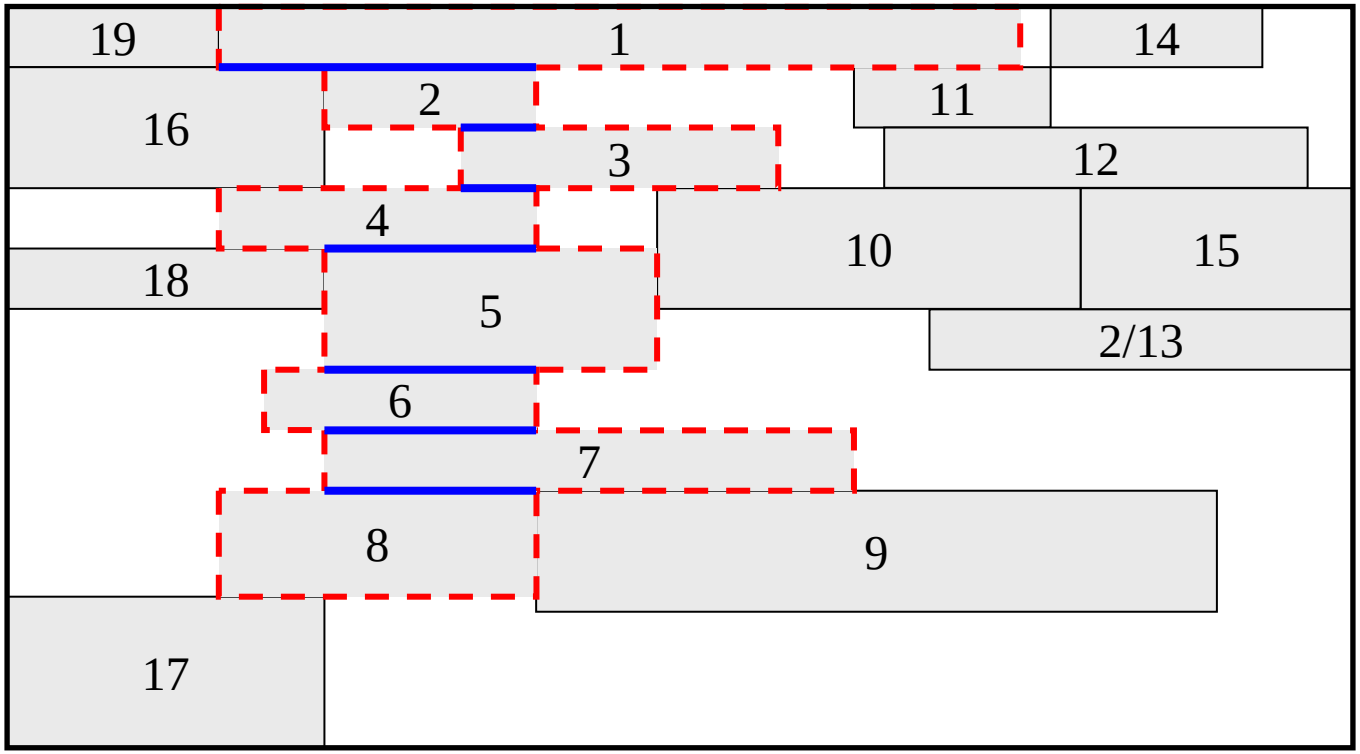
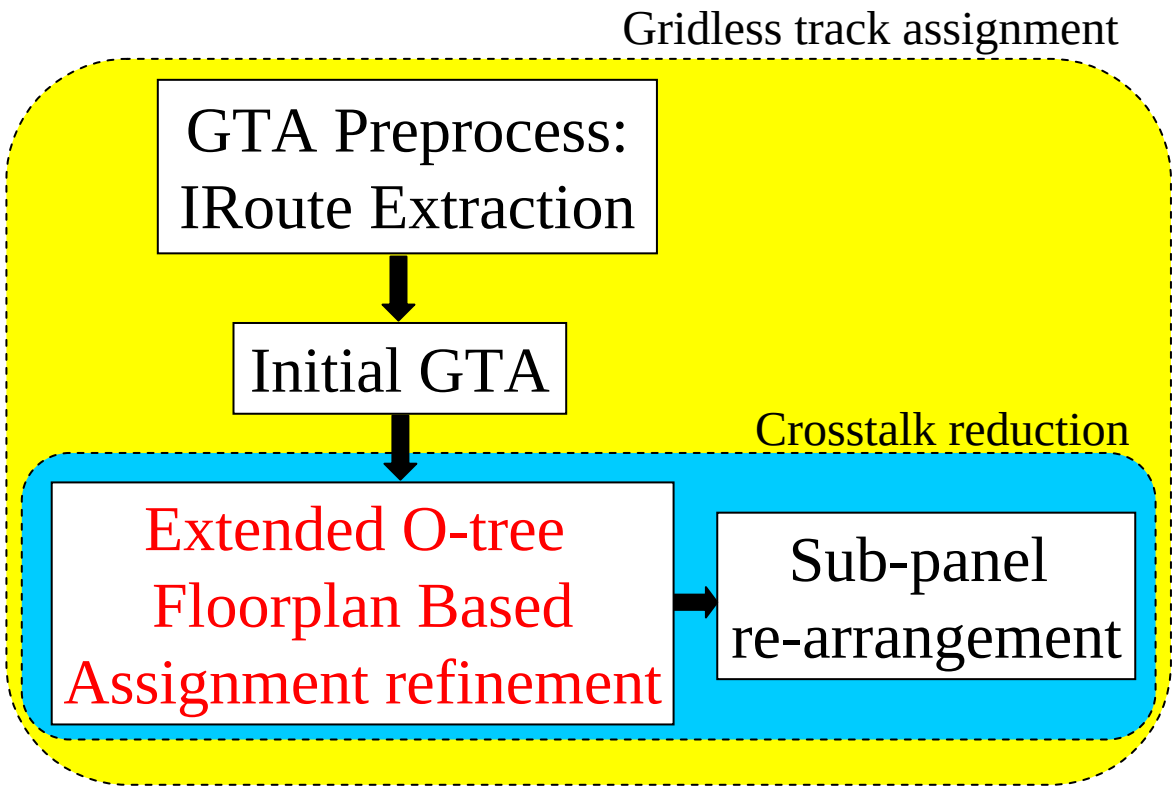
# Crosstalk-Driven GTA



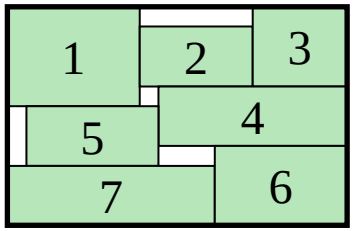
# Initial GTA



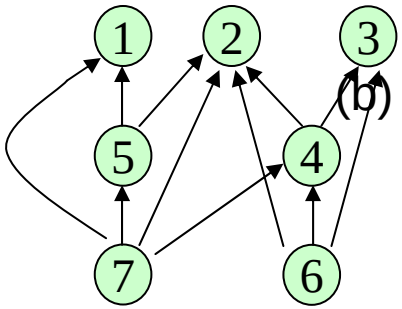
# Crosstalk-Driven GTA



# Extended O-Tree Based Assignment Refinement (EOBAR)

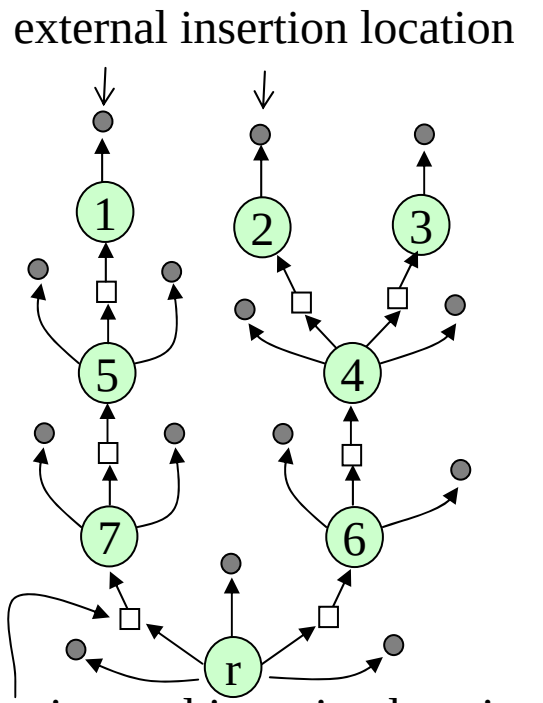



(a)



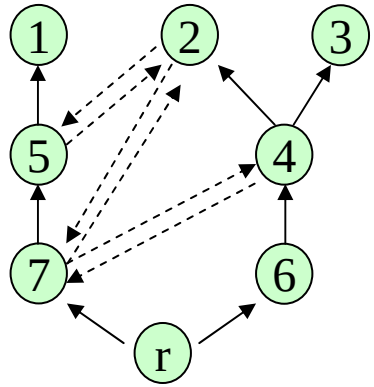

Overlap graph

(b)




O-tree

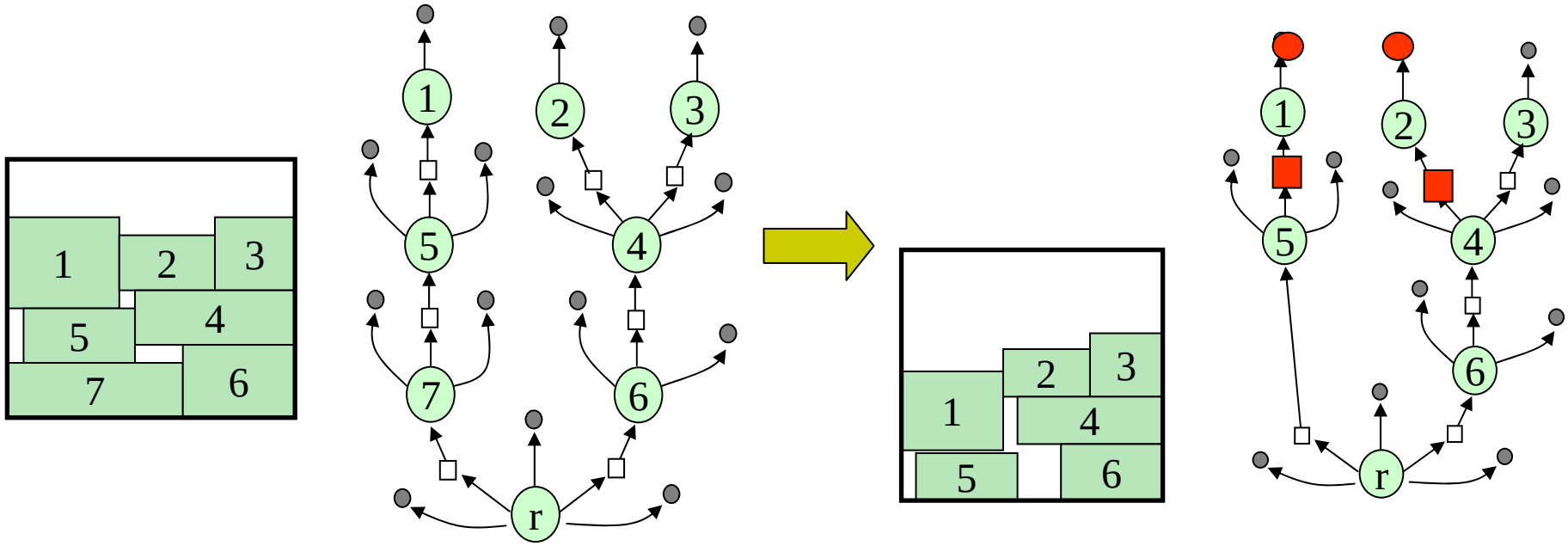
(c)




Extended O-tree

(d)

# Extended O-Tree Based Assignment Refinement



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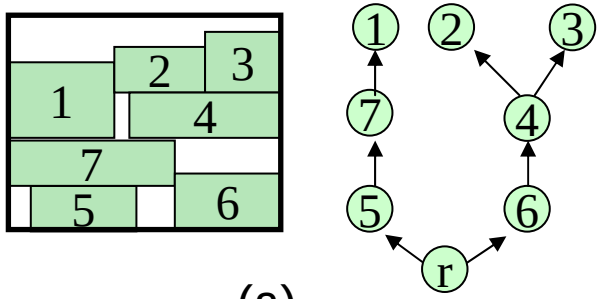
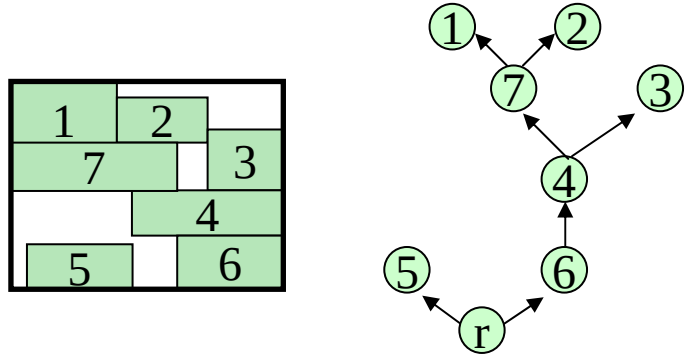
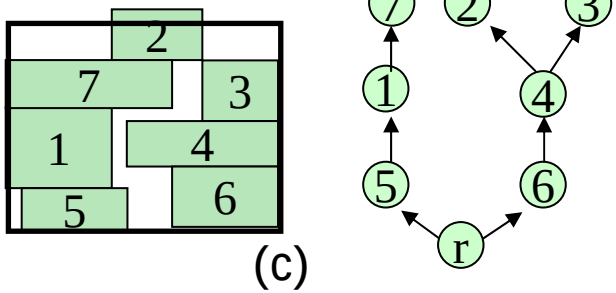



(a)

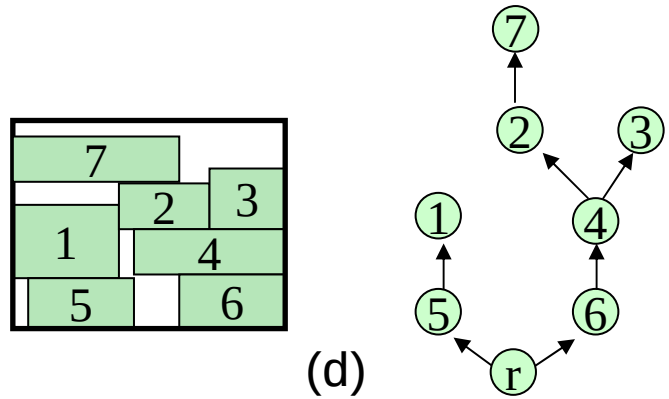



(b)




(c)

Infeasible

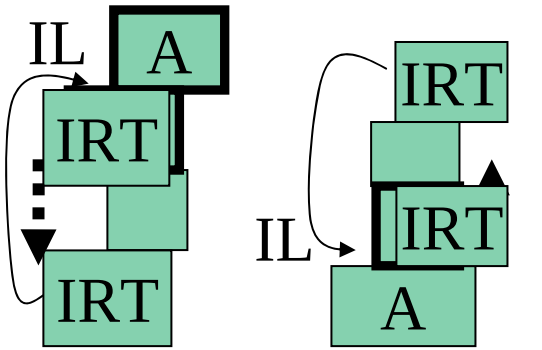



(d)

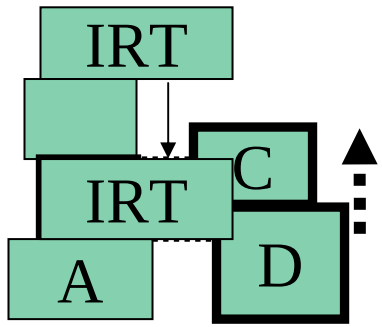
# Extended O-Tree Based Assignment Refinement

- Insertion is realized by tentative plow
  - IRT: IRoute under test

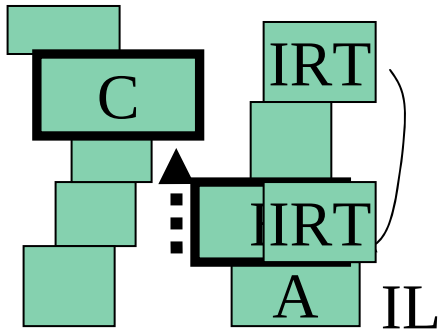
IL: Insertion Location  Plowing direction:




Type I: plow IRT path

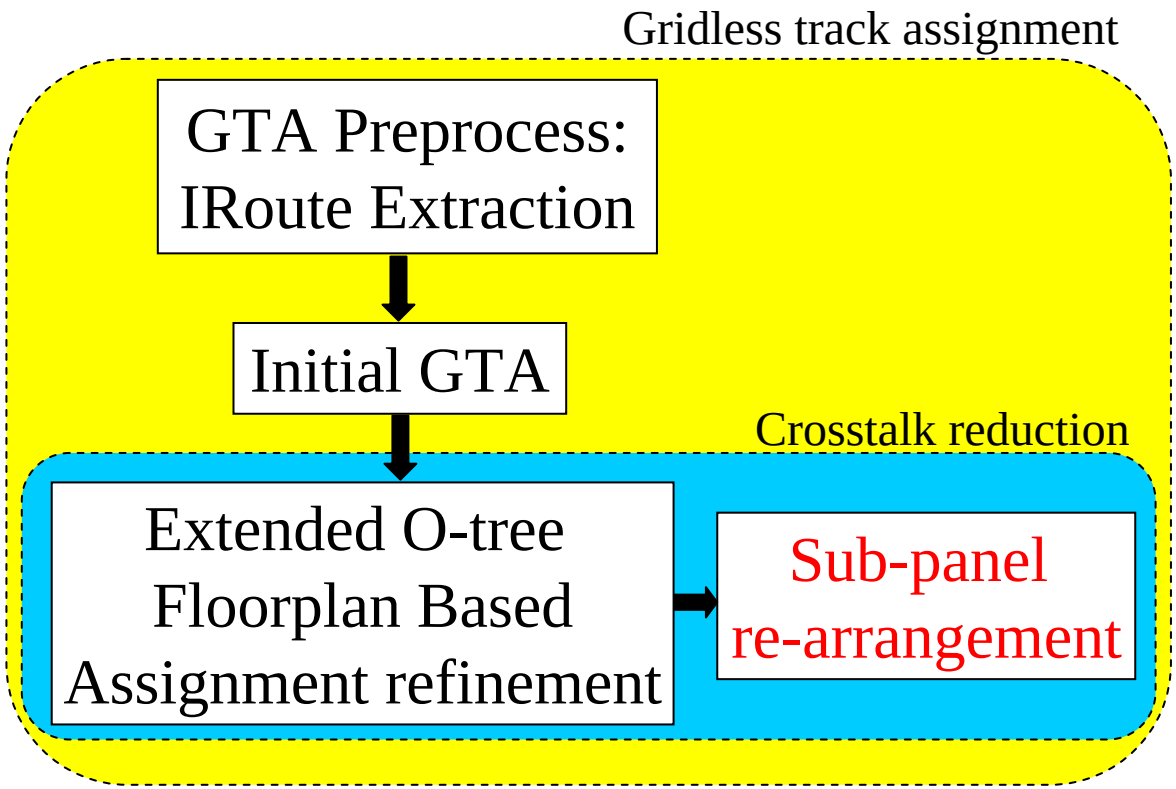



Type II: plow IRoute overlap to IRT

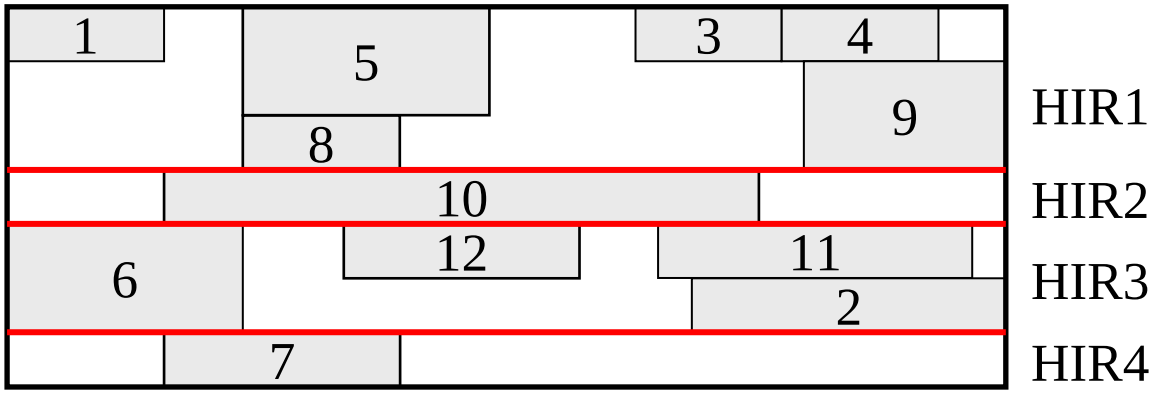


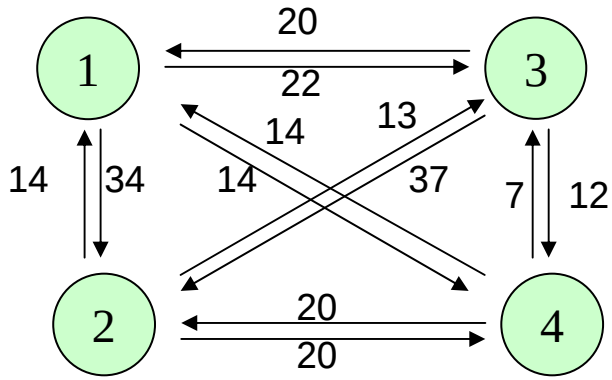

Type III: plow effect propagation to neighboring path

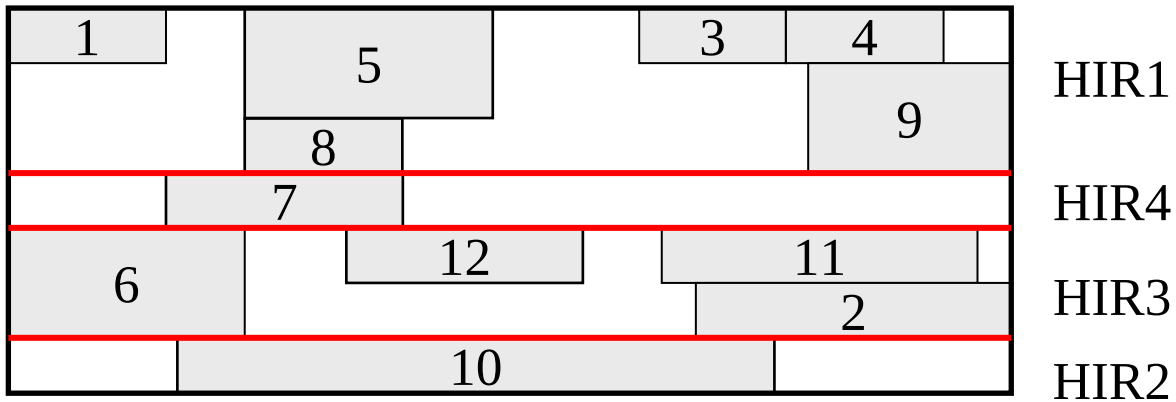
# Crosstalk-Driven GTA

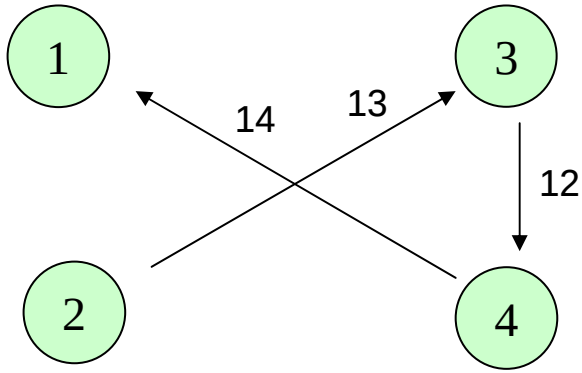


# Sub-panel Rearrangement



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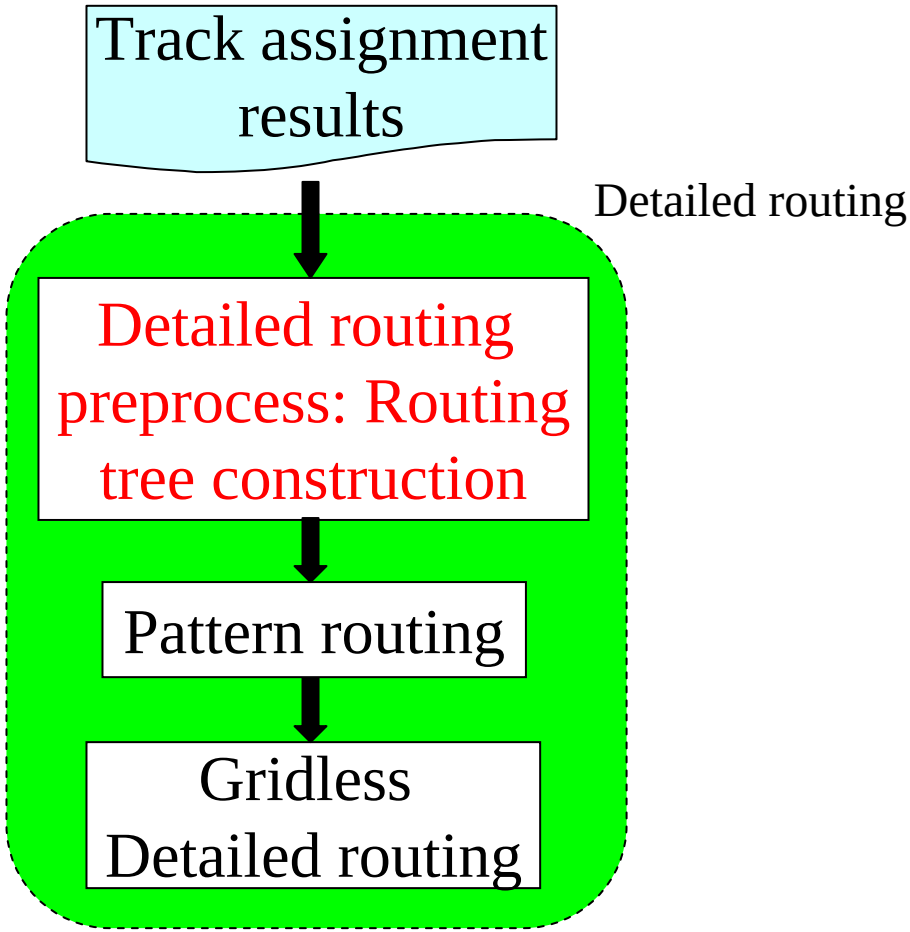
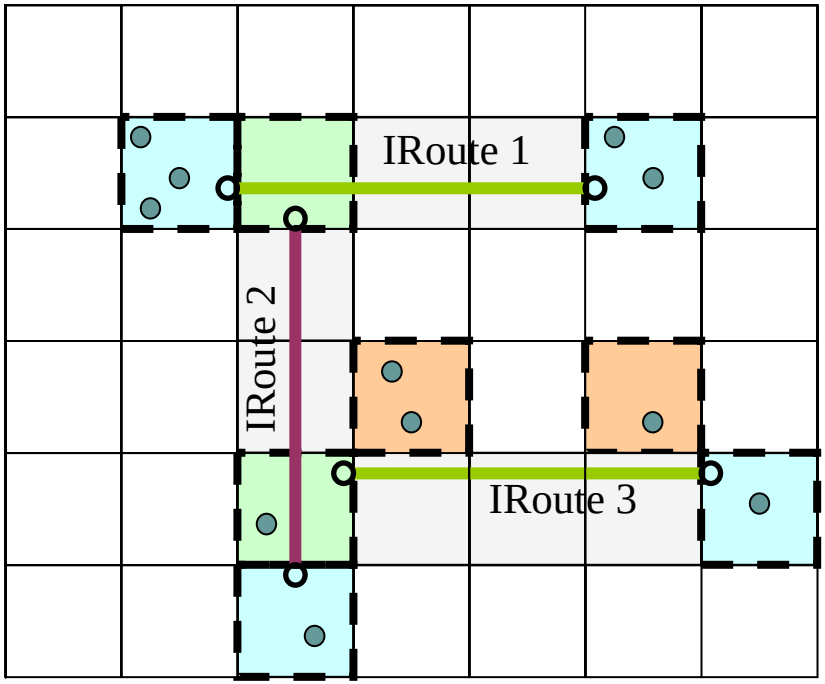
# Detailed routing

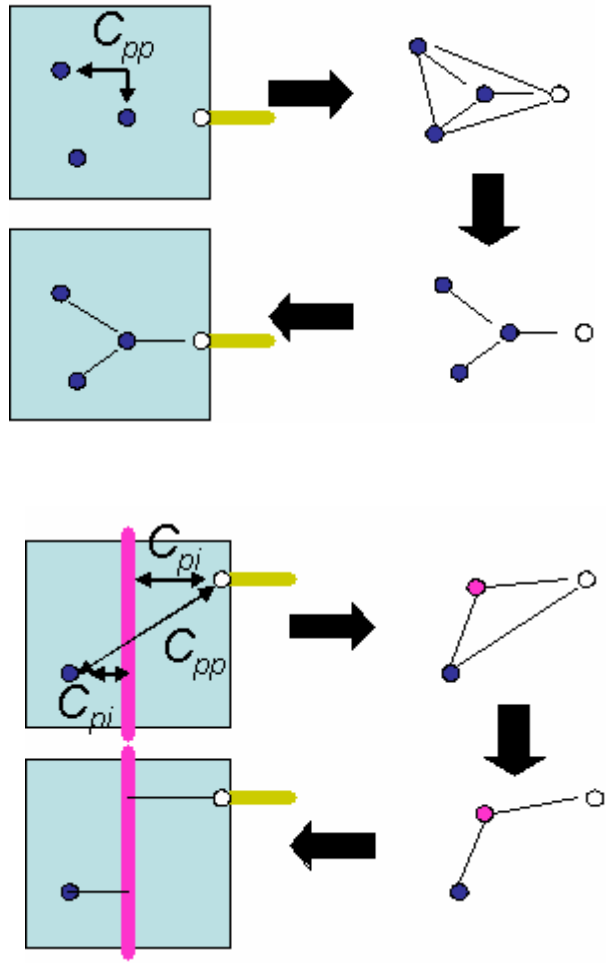


# Routing Tree Construction




Pin

Pseudo pin



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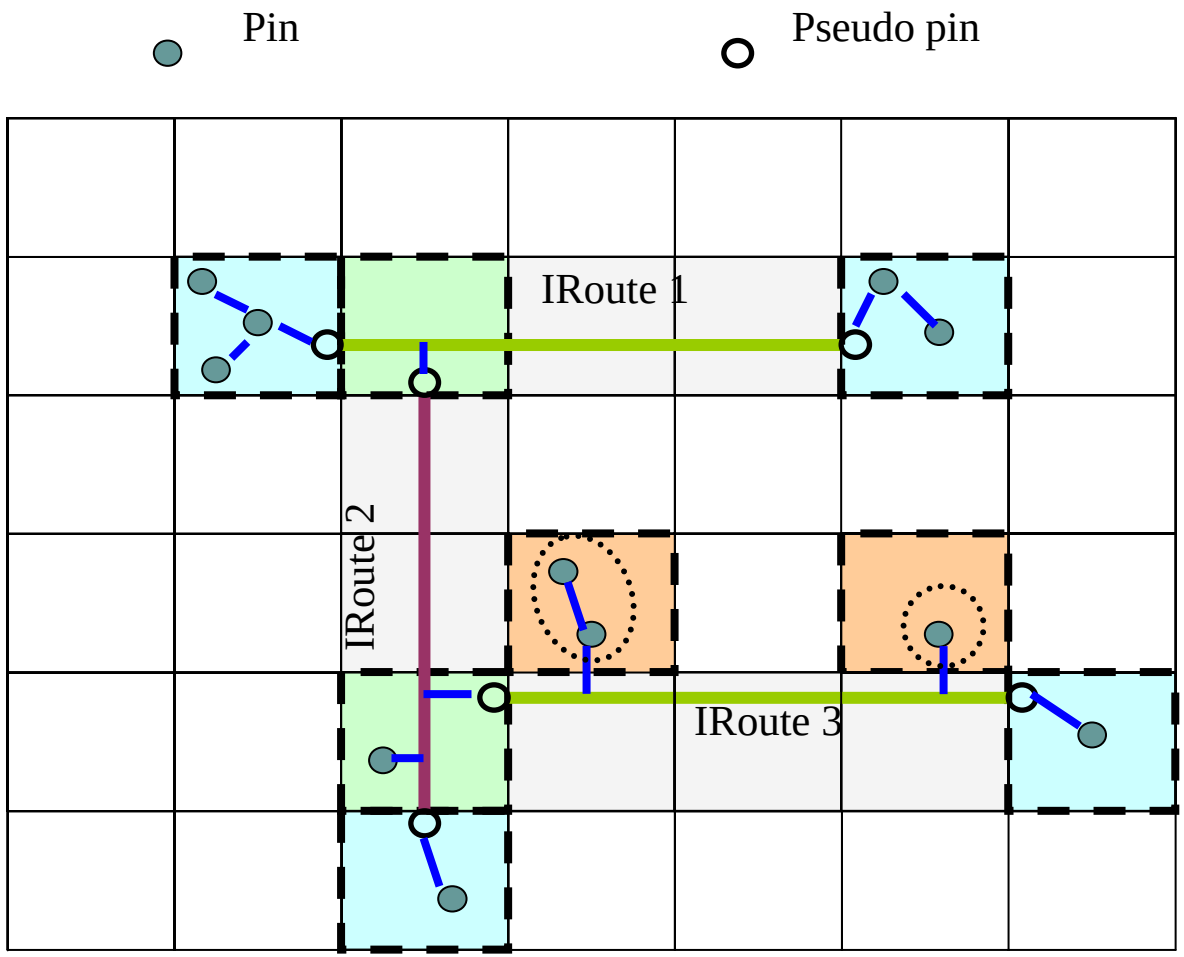

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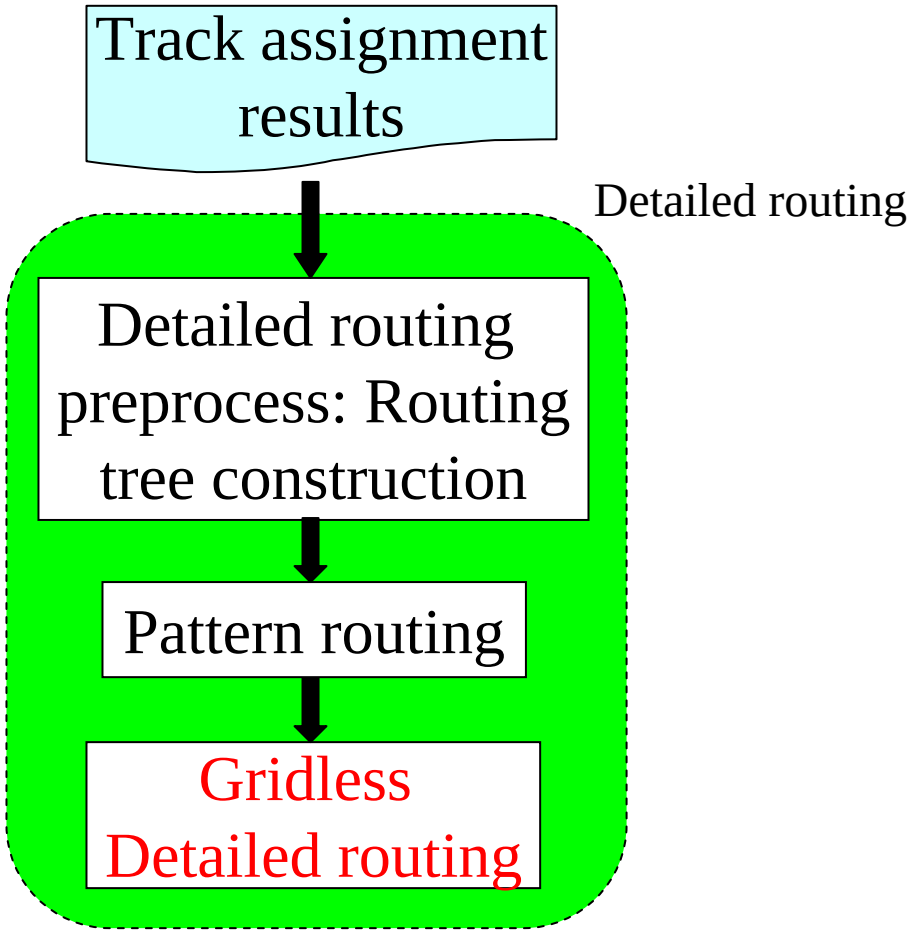
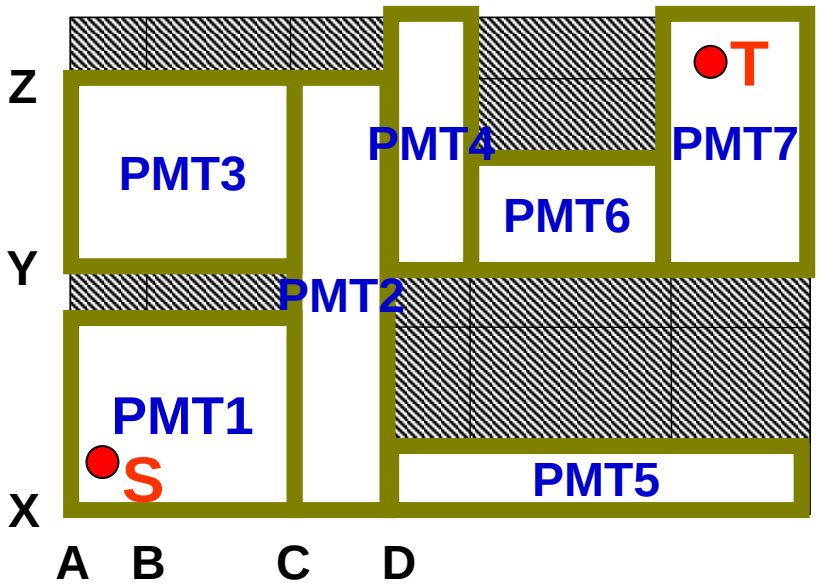
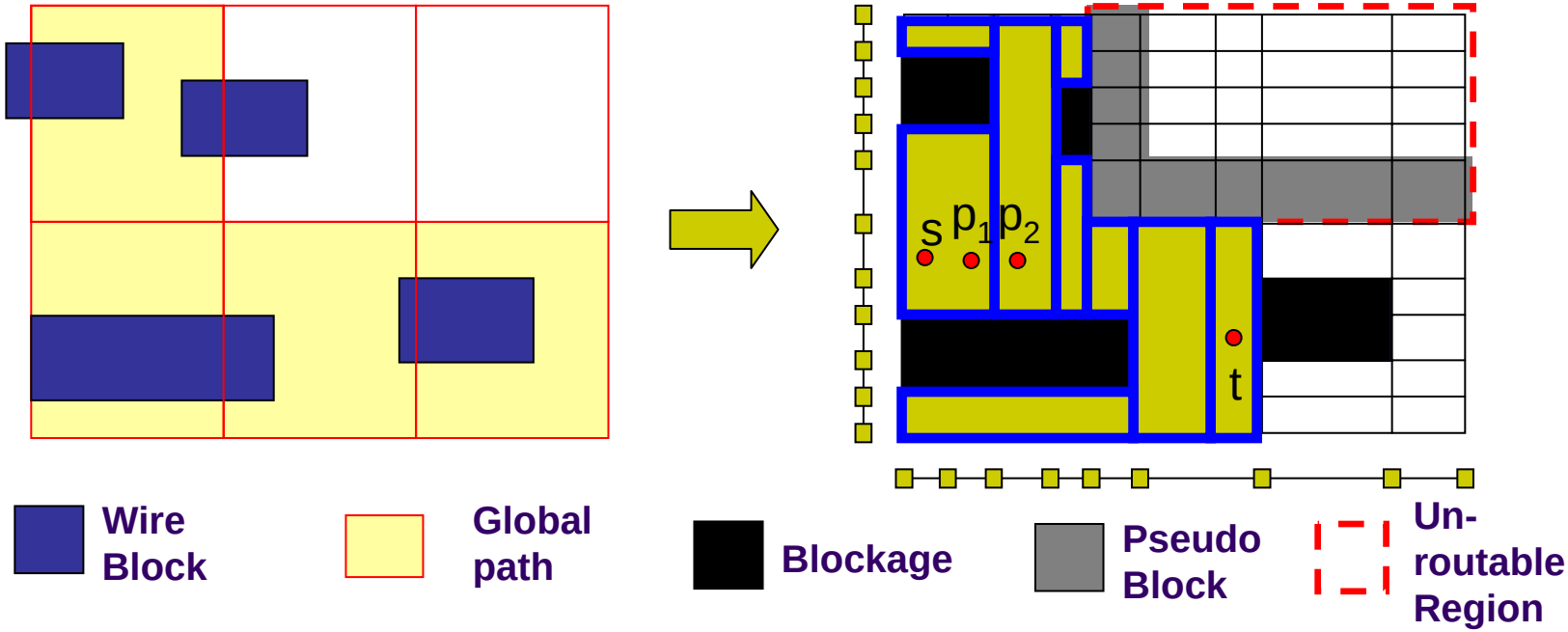


# Gridless Detailed Routing

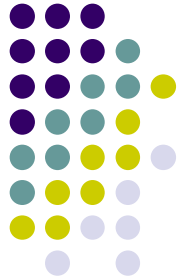


# Bin-Based Data Structure and Fast PMT Extraction




Bin-based data structure

# Experimental Results



- All routing cases were conducted on a 1.2GHz Sun Blade-2000 workstation with 2GB RAM
- Six MCNC benchmark circuits using three routing layers

# Experimental Results

**Table 1. Comparison of routing performance between NEMO and this work.**

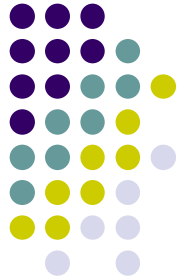
| | NEMO | | This work Fast PMT extraction | |
|---|---|---|---|---|
| | Time (Tn:sec) | Mem (MB) | Time (Tt:sec) | Mem (MB) |
| s5378 | 2.4 | 10 | 2.10 | 22 |
| s9234 | 1.7 | 9 | 1.45 | 21 |
| s13207 | 6.6 | 15 | 4.43 | 25 |
| s15850 | 8.8 | 18 | 6.51 | 27 |
| s38417 | 37.2 | 48 | 13.46 | 37 |
| s38584 | 73.7 | 66 | 30.52 | 45 |
| Tn/Tt | 1.72 | | 1 | |

# Experimental Results

**Table 2. Statistics of crosstalk reduction for fixed- and variable-rule routings.**

| Circuit | Initial assignment | | O-tree based refinement + HIR re-arrangement | | | |
|---|---|---|---|---|---|---|
| | Coupling cap. **x** $10^3$ (C1) | | Coupling cap. **x** $10^3$ (C2) | | RR (%) | |
| | **FR** | VR | **FR** | VR | **FR** | VR |
| S5378 | **.168** | .123 | **.075** | .091 | **55** | 26 |
| S9234 | **.107** | .086 | **.040** | .047 | **63** | 46 |
| S13207 | **.379** | .294 | **.160** | .205 | **58** | 30 |
| S15850 | **.493** | .363 | **.205** | .275 | **59** | 24 |
| S38417 | **1.013** | .794 | **.385** | .559 | **62** | 30 |
| S38584 | **1.402** | 1.026 | **.578** | .863 | **59** | 16 |
| Ave. | | | | | **59** | 29 |

# Experimental Results



•**Table 3. Comparison of routing results between this work and [13].**

| | Global Routing + NEMO | | | | Global Routeing + crosstalk driven GTA + fast PMT extraction NEMO | | | |
|---|---|---|---|---|---|---|---|---|
| | **Run time (sec)** | | W.L. ($\times 10^4 \mu m$ ) | | **Run time (sec)** | | W.L. ($\times 10^4 \mu m$ ) | |
| | **FR** | VR | **FR** | VR | **FR** | VR | **FR** | VR |
| s5378 | **2.4** | 3.74 | **7.4** | 7.6 | **1.70** | 2.31 | **8.0** | 8.2 |
| s9234 | **1.7** | 2.69 | **5.5** | 5.6 | **1.25** | 1.72 | **6.0** | 6.1 |
| s13207 | **6.6** | 11.28 | **17** | 18 | **4.13** | 7.62 | **19** | 19 |
| s15850 | **8.8** | 16.33 | **22** | 22 | **5.34** | 8.33 | **23** | 24 |
| s38417 | **37.2** | 56.36 | **48** | 49 | **14.04** | 15.75 | **52** | 52 |
| s38584 | **73.7** | 143.39 | **67** | 68 | **22.65** | 27.64 | **72** | 72 |
| Comp. | **2.66** | 4.17 | **0.93** | 0.94 | **1** | 1 | **1** | 1 |

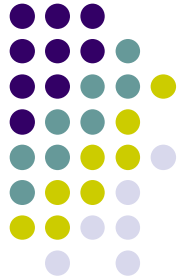
# Experimental Results

**Table 4. Comparison of fixed-rule routing results of a commercial routing tool and this work.**

| circuit | Run time (sec) | | Wire length ($\times 10^4 \mu m$) | | Coupling capacitance (pf) | |
|---|---|---|---|---|---|---|
| | This work | CR wt SI | This work | CR wt SI | This work | CR wt SI |
| s5378 | 1.70 | 16 | 8.0 | 7.7 | 3.88 | 4.67 |
| s9234 | 1.25 | 14 | 6.0 | 5.7 | 2.28 | 2.72 |
| s13207 | 4.13 | 43 | 19 | 18 | 8.38 | 9.74 |
| s15850 | 5.34 | 49 | 23 | 23 | 11.29 | 13.77 |
| s38417 | 14.04 | 110 | 52 | 50 | 21.78 | 23.68 |
| s38584 | 22.65 | 157 | 72 | 69 | 32.69 | 37.06 |
| Comp. | 1 | 7.92 | 1 | 0.96 | 1 | 1.17 |

# Conclusion

- This work presents a three-stage gridless routing system
- Experimental results reveal that the proposed gridless routing system can perform over 2.66 times faster than NEMO.
- As compared with a commercial routing tool, this work yields an average runtime speedup of 7.92 times and an average 15% reduction rate in coupling capacitance



# Thank you