

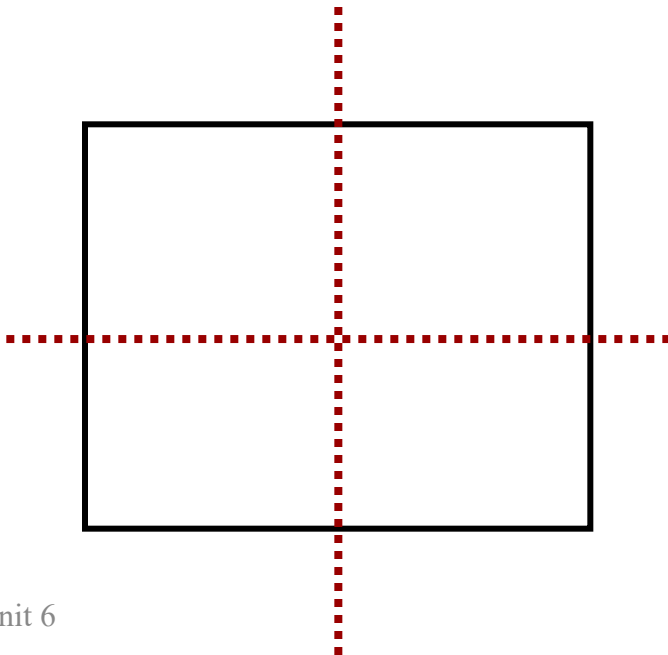
Hierarchical Routing Framework

- The hierarchical approach recursively divides a routing region into a set of subregions and solve those subproblems independently.
- Drawbacks: lack the global information for the interaction among subregions.



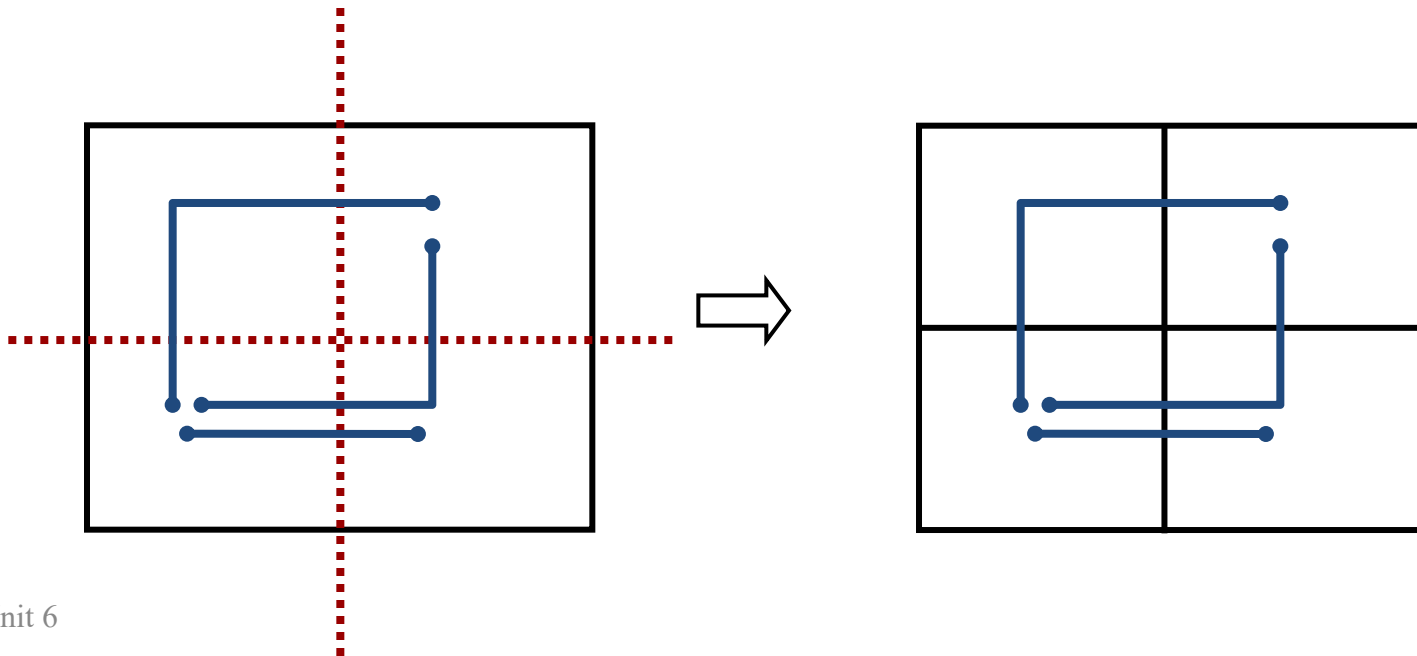
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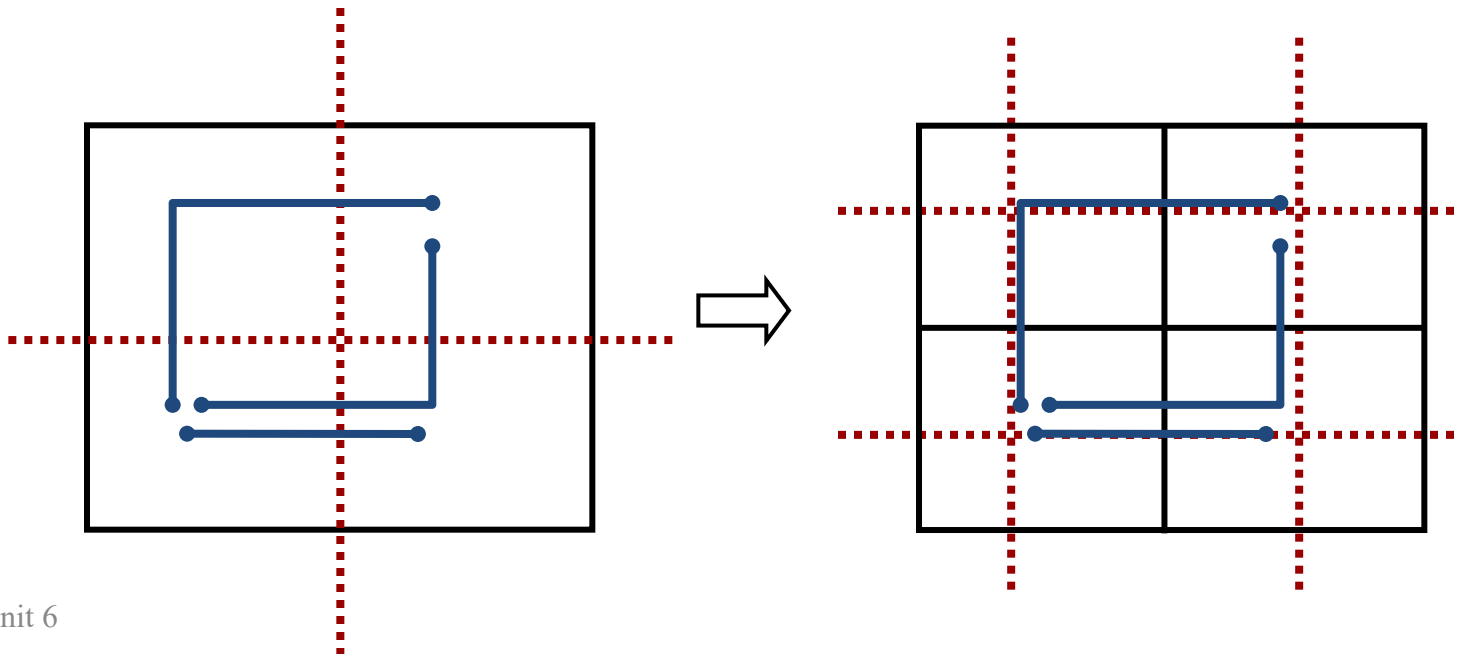
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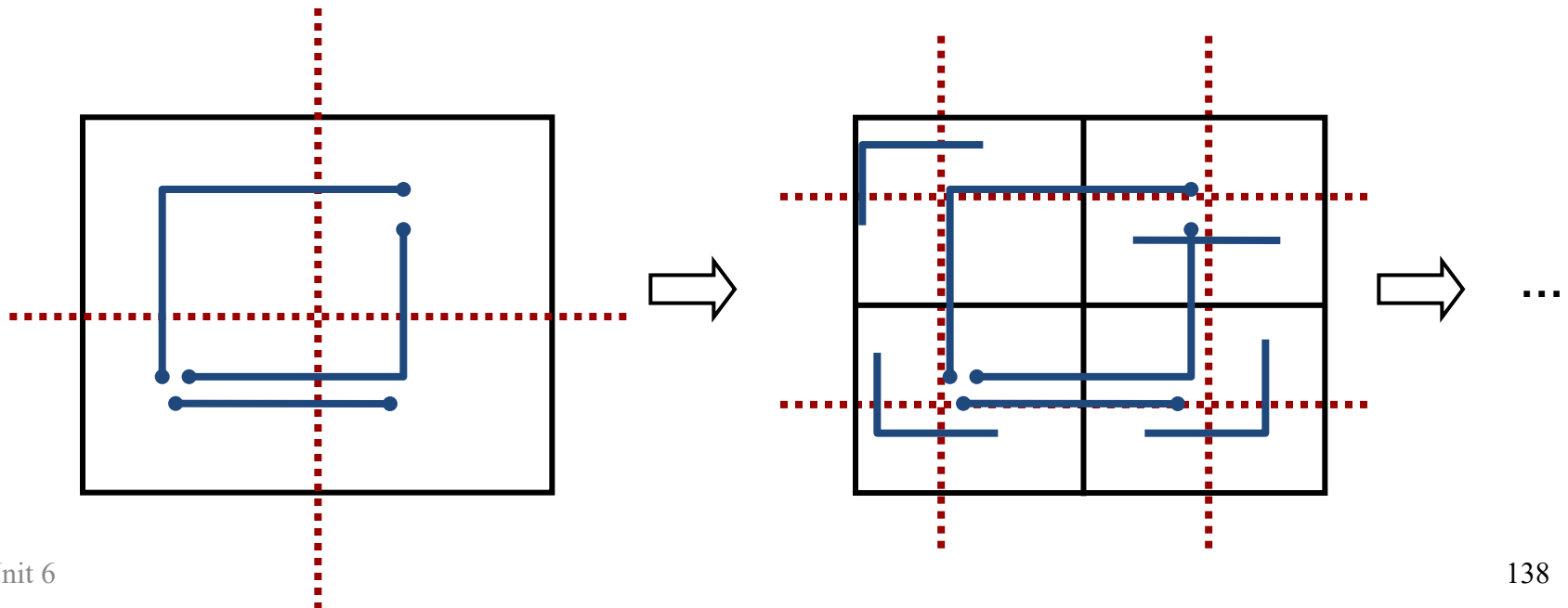
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Multilevel Full-Chip Routing Framework

- Lin and Chang, “A novel framework for multilevel routing considering routability and performance,” ICCAD-02 (TCAD-03).
- Multilevel framework: coarsening followed by uncoarsening.
- Coarsening (bottom-up) stage:
 - Constructs the net topology based on the minimum spanning tree.
 - Processes routing tiles one by one at each level, and only local nets (connections) are routed.
 - Applies two-stage routing of global routing followed by detailed routing.
 - Uses the L-shaped & Z-shaped pattern routing.
 - Performs resource estimation after detailed routing to guide the routing at the next level.
- Uncoarsening (top-down) stage
 - Completes the failed nets (connections) from the coarsening stage.
 - Uses a global and a detailed maze routers to refine the solution.

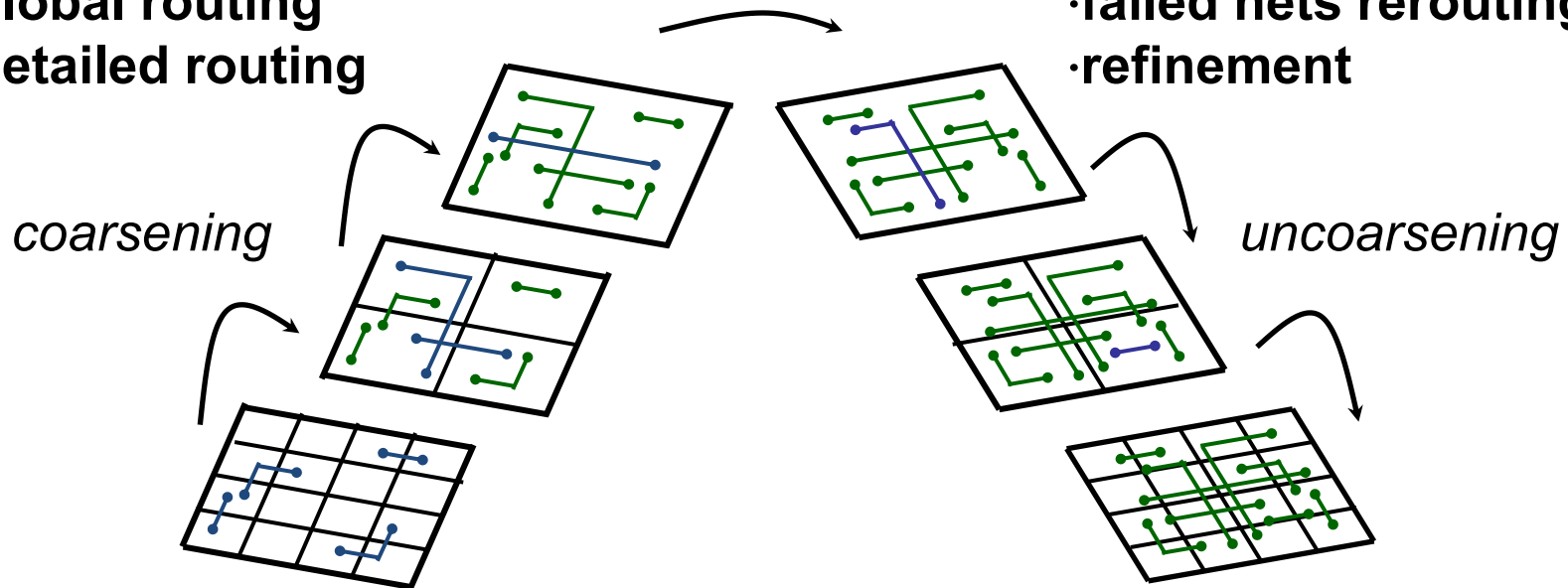
Λ -Shaped Multilevel Routing Framework

----- To-be-routed net

————— Already-routed net

- global routing
- detailed routing

- failed nets rerouting
- refinement



Perform global pattern & detailed routing for local connections and then estimate routing congestion for the next level

Use maze routing to reroute failed connections and refine the solution

Cost: congestion + net length

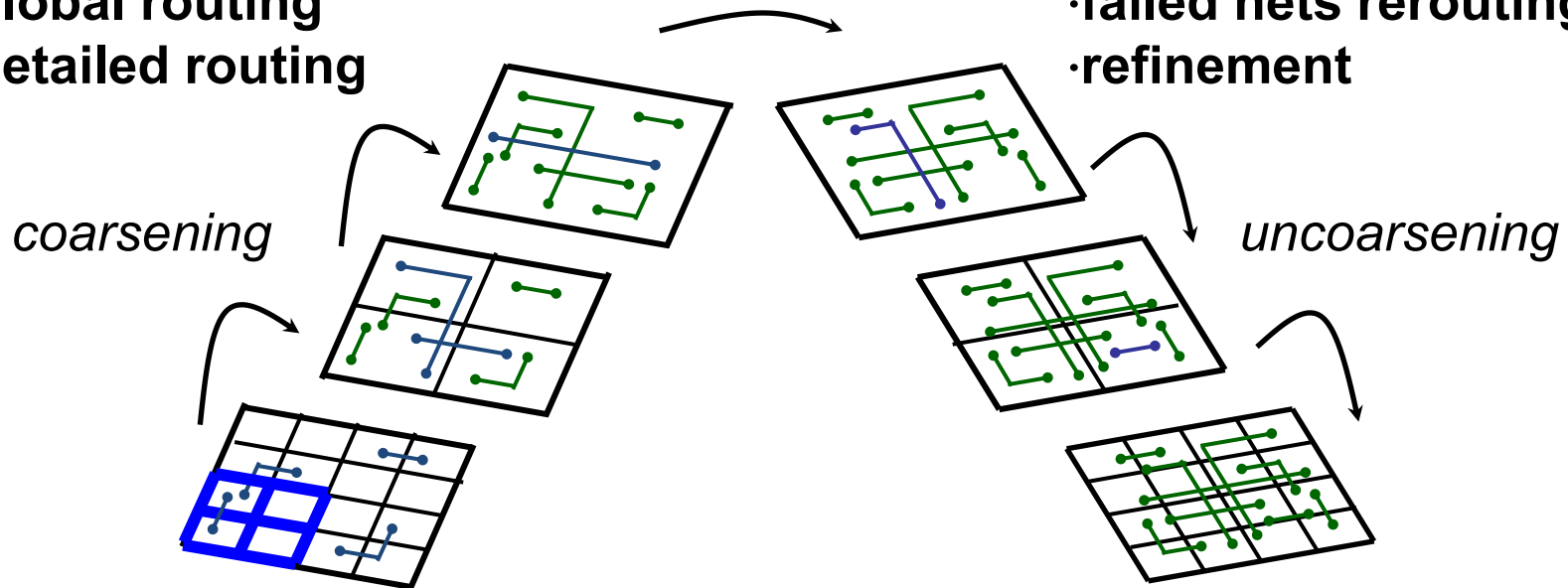
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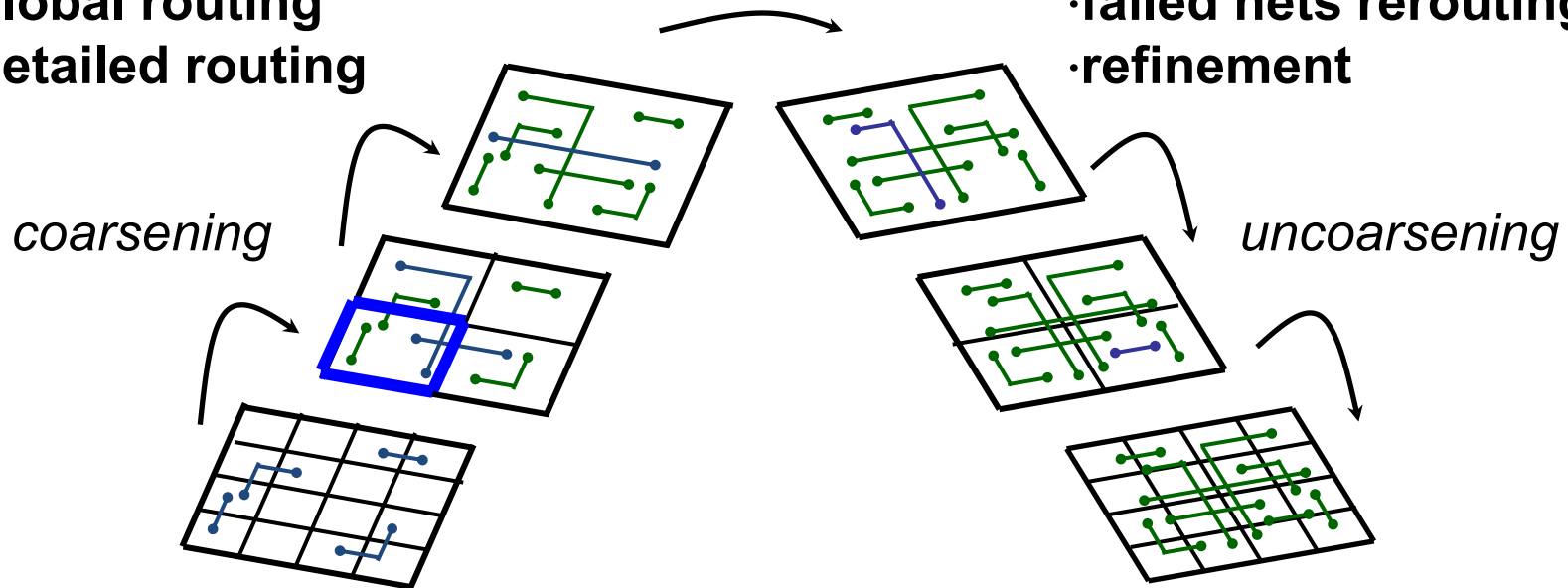
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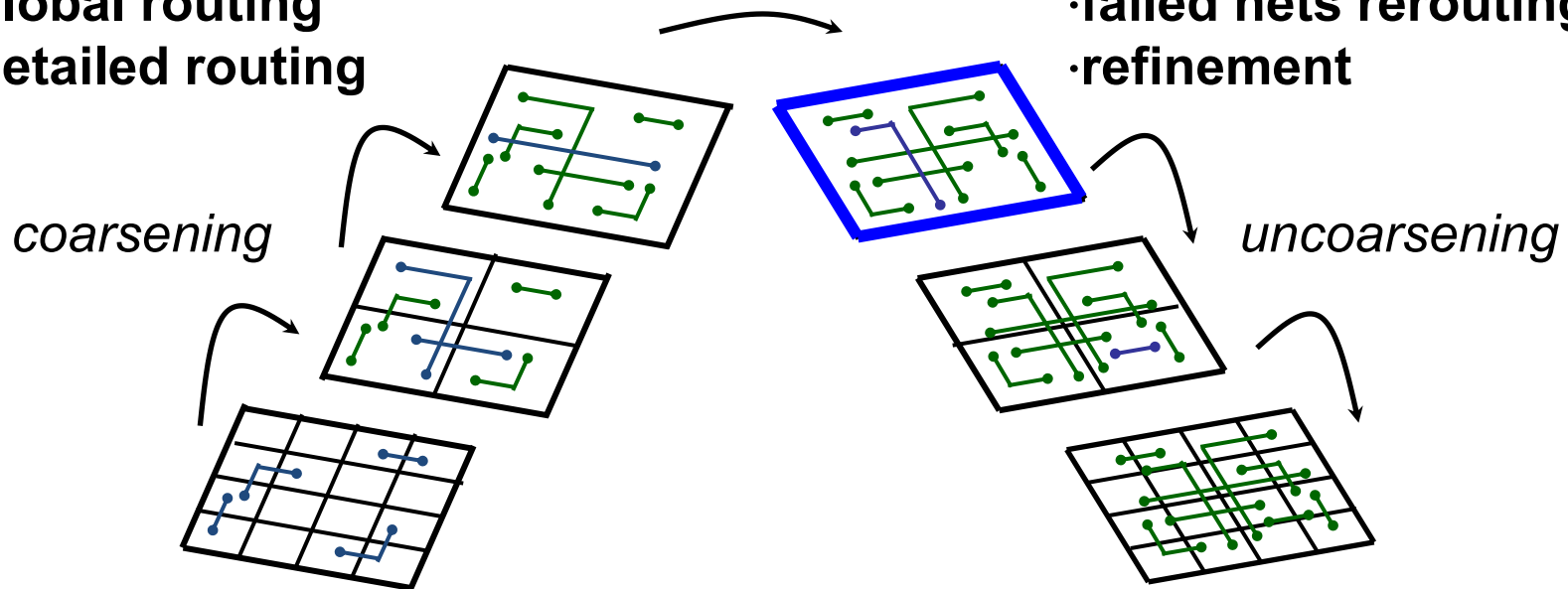
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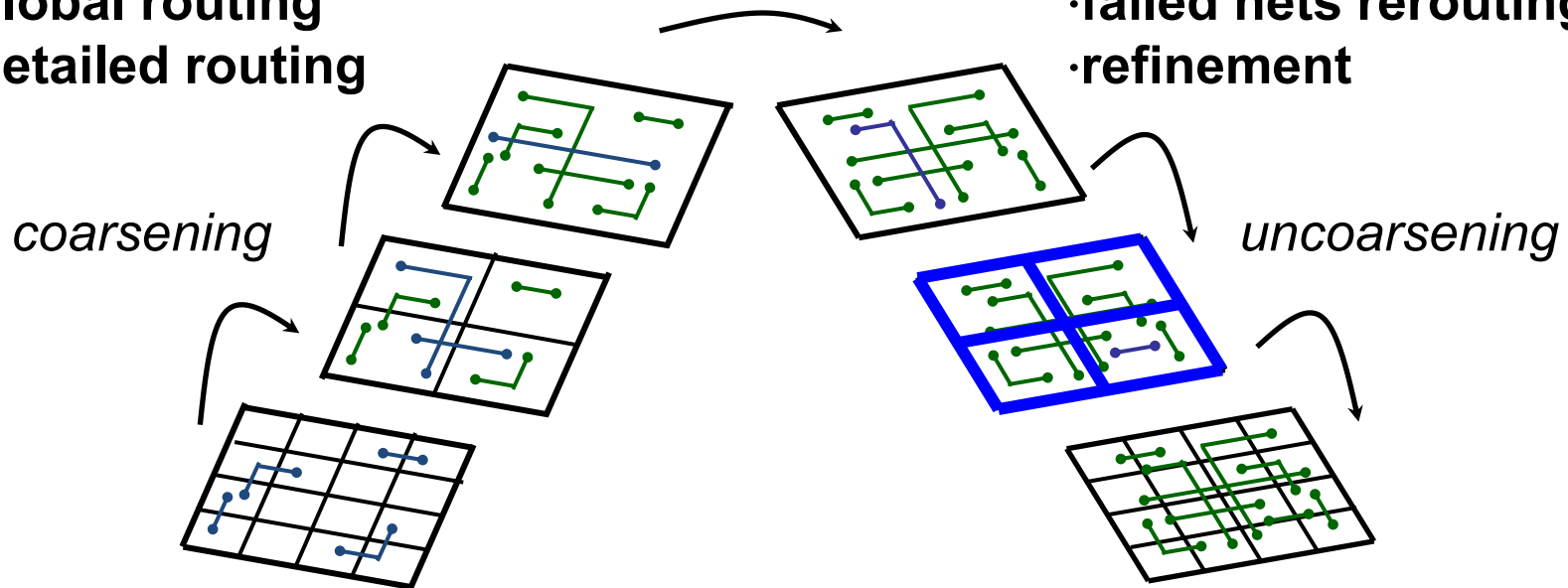
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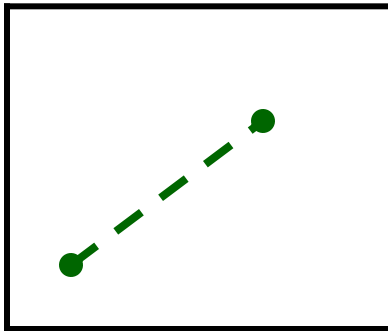
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Coarsening Stage

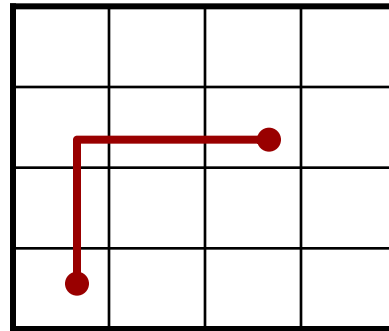
- Build MSTs for all nets and decompose them into two-pin connections.
- Route **local nets (connections)** from level 0.
 - Two-stage routing (global + detailed routing) for a local net.

— an MST edge



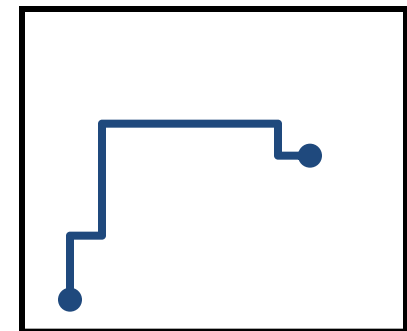
level k

— global route



level 0

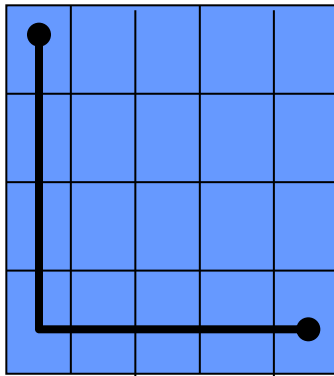
— detailed route



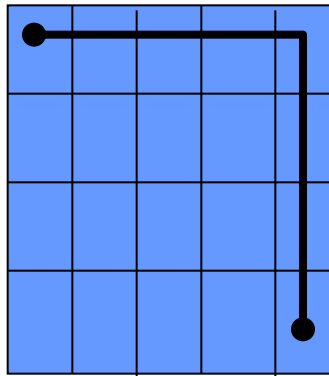
level k

Global Routing

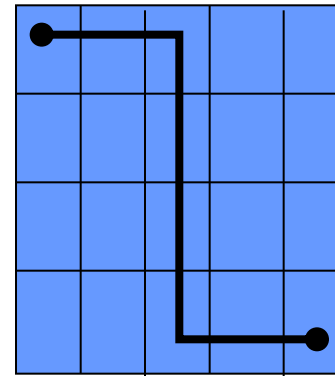
- Apply pattern routing for global routing
 - Use L-shaped and Z-shaped connections to route nets.
 - Has lower time complexity than maze routing.



**Lower L-Shaped
connection**



**Upper L-Shaped
connection**



**Z-Shaped
connection**

Cost Function in Global Pattern Routing

$G_i = (V_i, E_i)$: multilevel routing graph at level i .

Define $R_e = \{e \in E_i \mid e \text{ is the edge chosen to route}\}$

Then

$$\text{cost}(R_e) = \sum_{e \in E} C_e,$$

where C_e is the congestion of edge e
and

$$C_e = \frac{1}{2^{(p_e - d_e)}},$$

where p_e and d_e are the capacity and density associated with e , respectively.

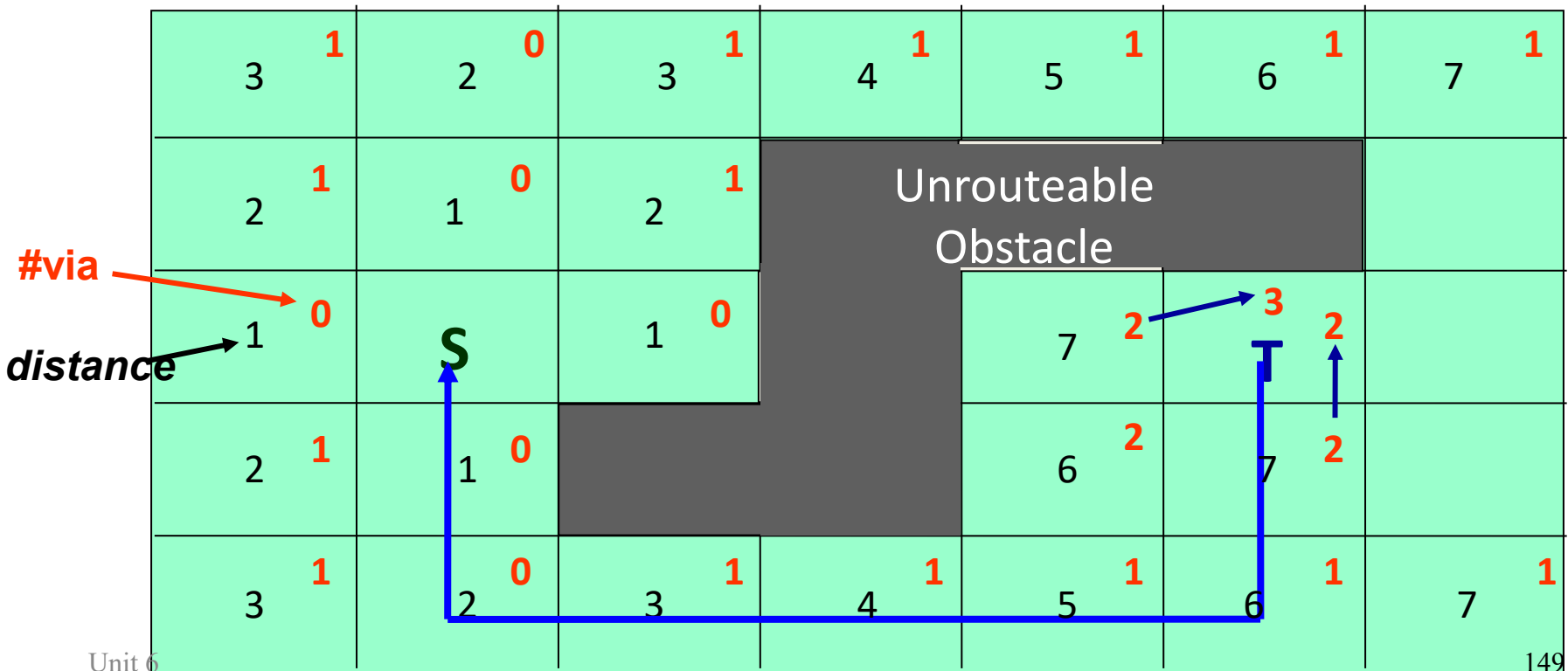
Detailed Routing

- Via minimization
 - Modify the maze router to minimize the number of bends.
- Local refinement
 - Apply general maze routing to improve the detailed routing results.
- Resource estimation
 - Update the edge weights of the routing graph after detailed routing.

Via Minimization

- Simultaneous pathlength and via minimization (SPVM)
 - perform modified maze routing that simultaneously considers the pathlength and via minimization

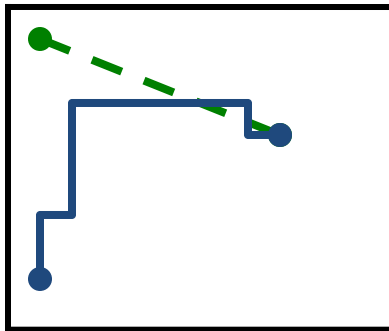
Back Trace



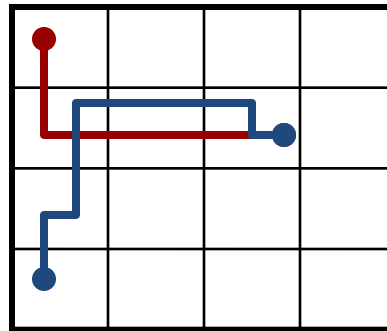
Local Refinement

- Local refinement improves detailed routing results by merging two connections which are decomposed from the same net.

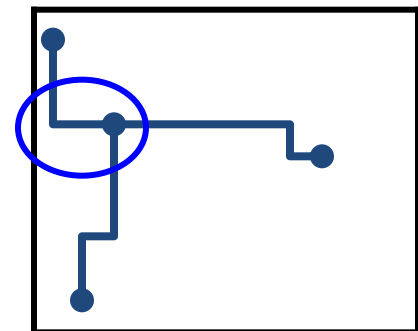
— an MST edge — global route — detailed route



level k



level 0



level k

Resource Estimation

- Global routing cost is the summation of congestions of all routed edges.
- Define the congestion, C_e , of an edge e by

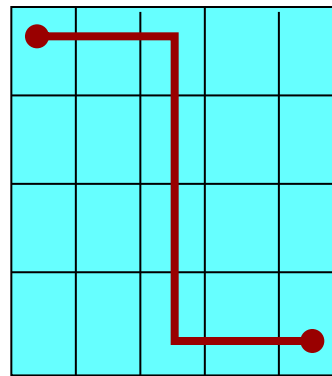
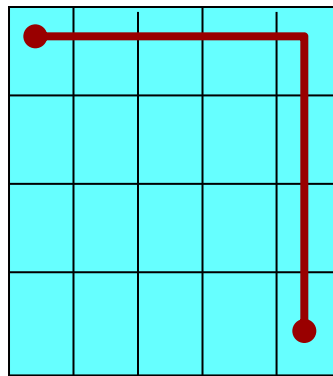
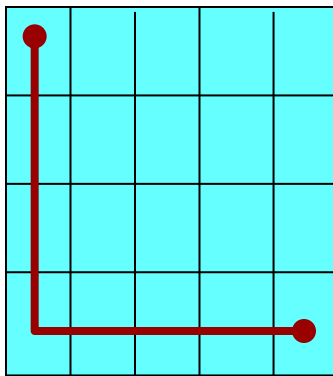
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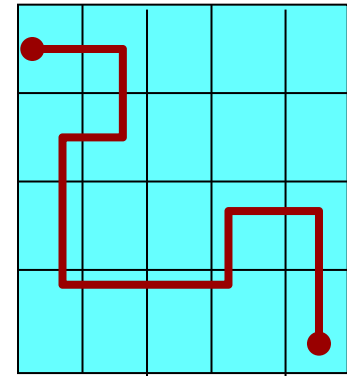
- Update the congestion of routed edges to guide the subsequent global routing.

Uncoarsening Global Routing

- Use maze routing.
- Iterative refinement of a failed net is stopped when a route is found or several tries have been made.



Coarsening stage



Uncoarsening stage