Stability and Scalability in Global Routing

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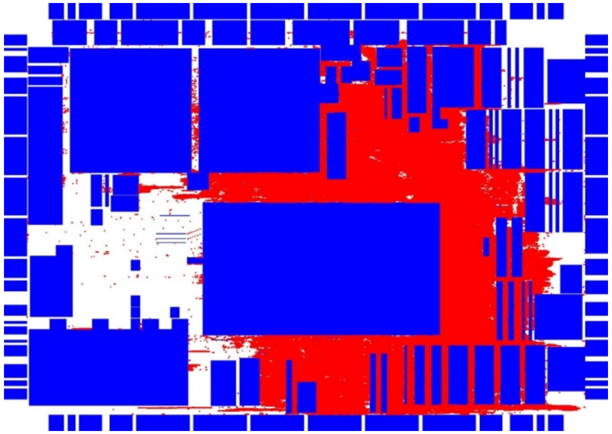
System-Level Interconnect Prediction Workshop
June 5, 2011

Outline

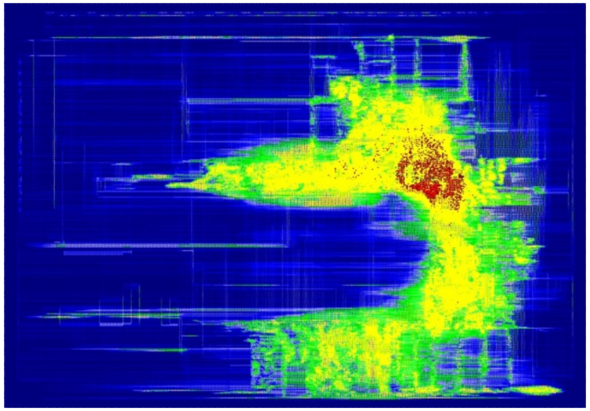
- Motivation
- Routing Estimation
- Experiments
- Conclusions

Motivation: Evaluation of Routability

- **Must avoid unroutable placement results**
  - **Loop back to placement after routing fails == too expensive!**
- **Routability determination during placement is critical but difficult**
  - **Built-in congestion estimators in modern placers**



Placement Result



Routing Result

Congestion Estimation During Placement

- **Static, non-constructive**
  - **Fixed L-Z shape models**
  - **Equal-probability models**
  - **#bends-based probabilistic models**
  - **Testcase-independent models**

  → too wide a gap between estimates and actual routing outcomes

- **Constructive**
  - **Integrated global router (under the hood of placement tool)**
  - **Helps P&R convergence**

  → global router must be high-quality and fast to serve in this role

This Work

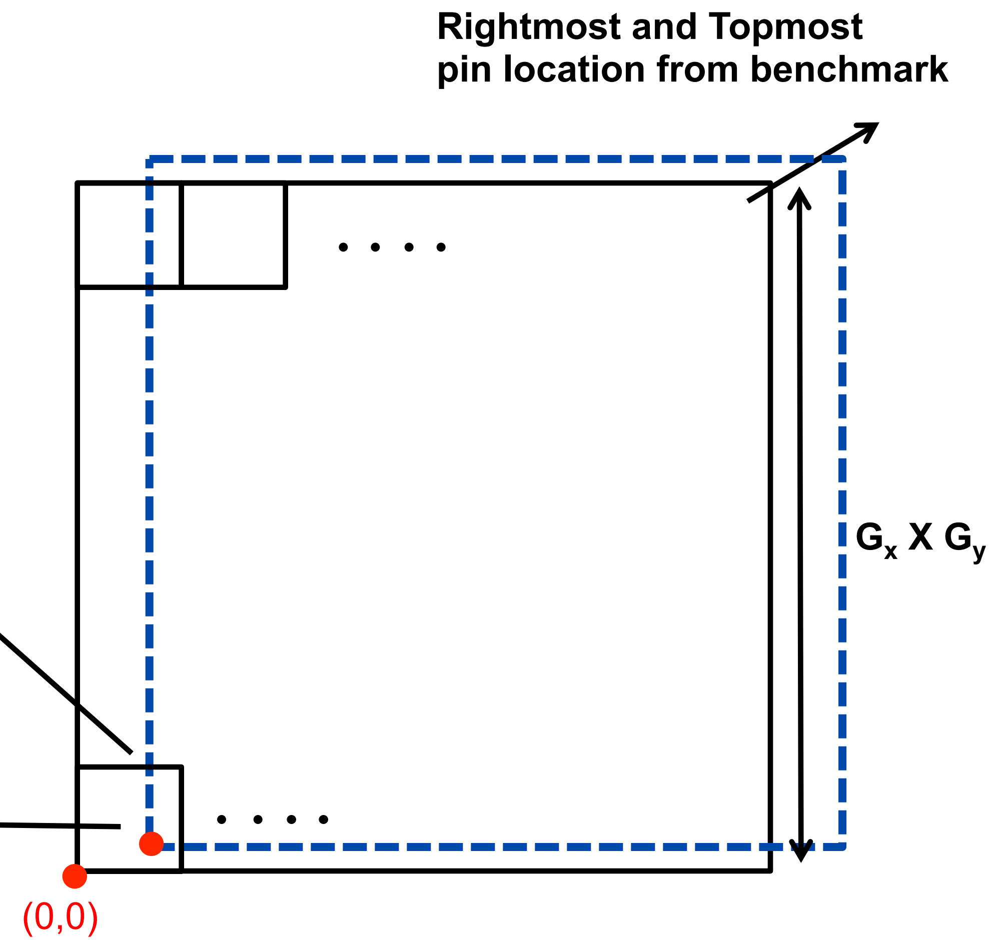
- ***How good can a routing estimator be?***
- **One way to answer this question: How noisy or inherently unpredictable is the routing (or, router) that we're trying to estimate?**
- **We experimentally assess "inherent unpredictability":**
  - **Routing grid offset noise**
  - **Routing resource noise**
  - **Routing instance scaling**
- **We discover stability, scalability limits of global routers**

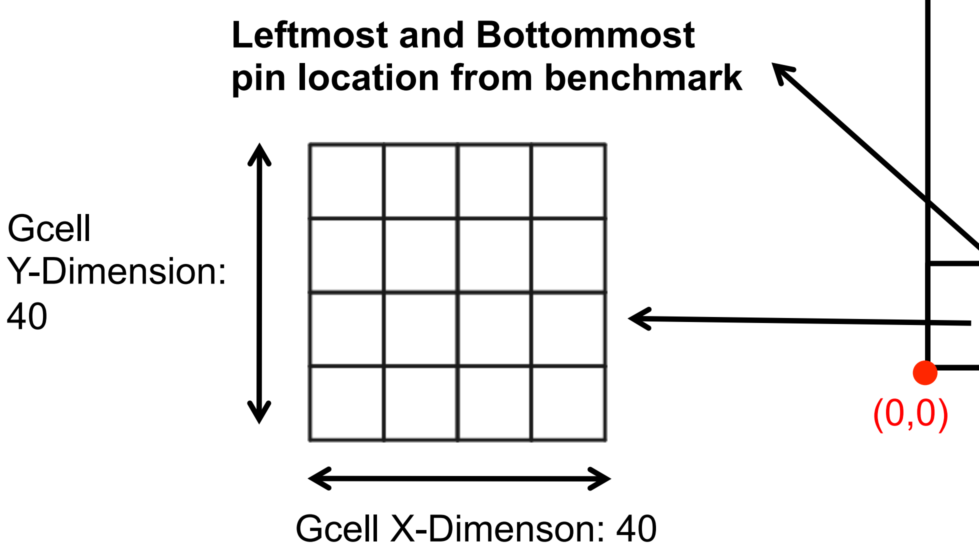
Testbed (based on ISPD Global Routing Contest)

- **Routing quality metrics**
  - *TOF* **(total overflow)**
  - *MOF* **(maximum *gedge-overflow*)**
  - *WCI(A)* **(Worst congestion index)**
  - *U(A)* **(Average net-score)**
- **ISPD-2008 Global Routing Benchmark Suite**
- **Four academic global routers**
  - **FastRoute-4.1**
  - **NTHU-2.0**
  - **FGR-1.2**
  - **NTUgr-1.1**

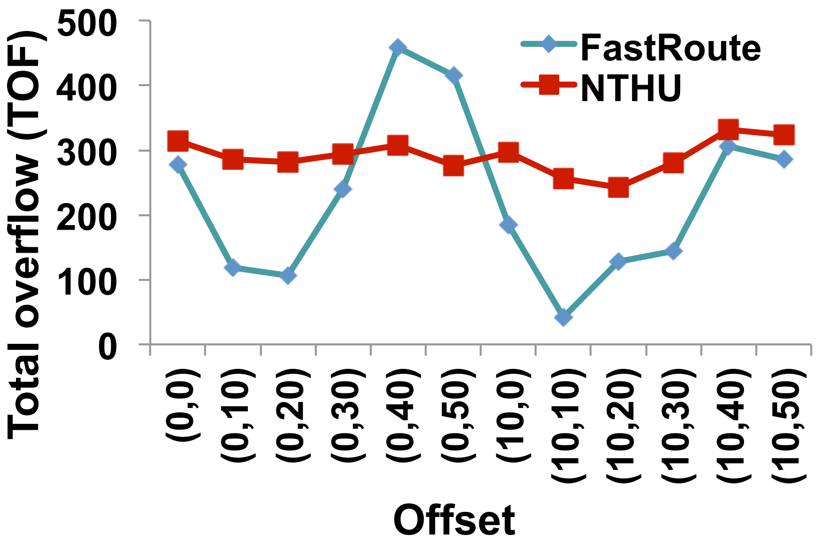
Experiment 1: Offset Noise

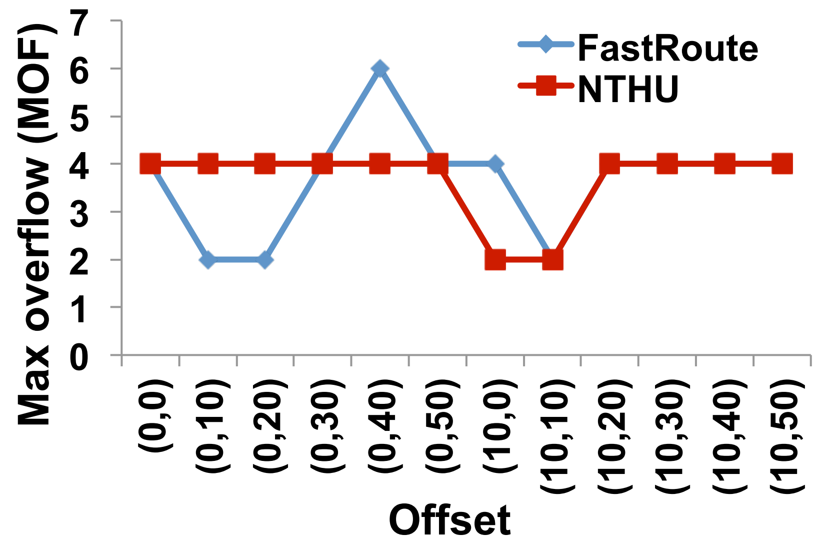
- **Estimation on stability to *grid-offset* noise**
  - Shift the origin of the gcell array horizontally and vertically
  - Constraint on offset: all pins should be covered

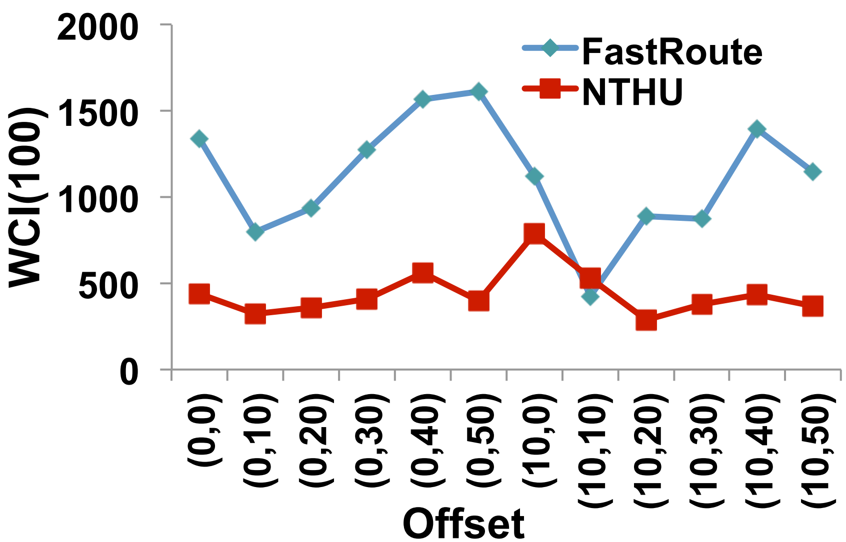


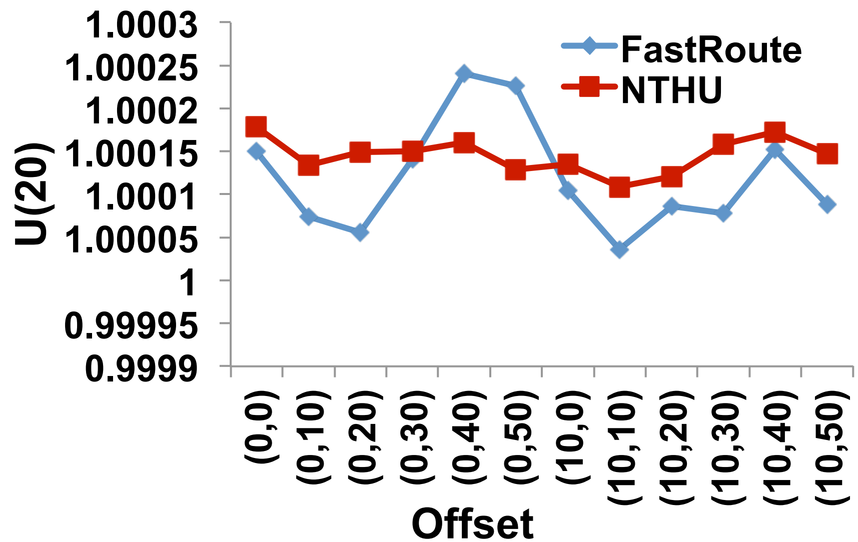


Offset Noise Experimental Results



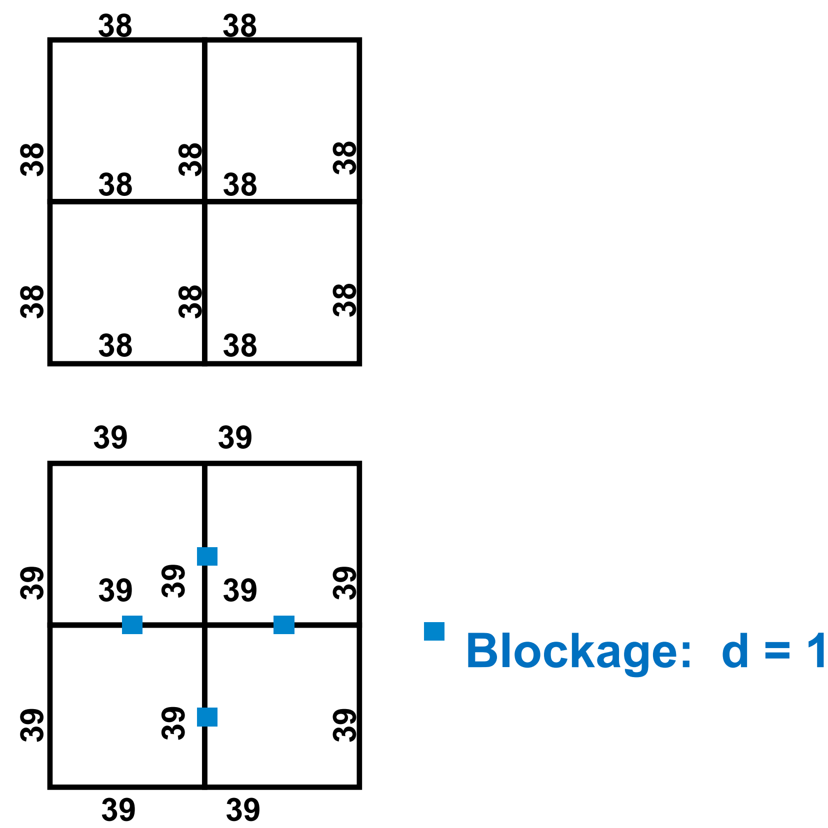




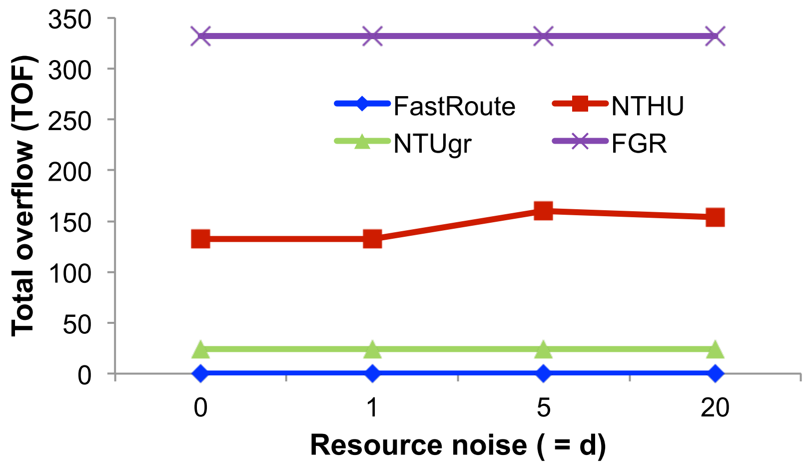


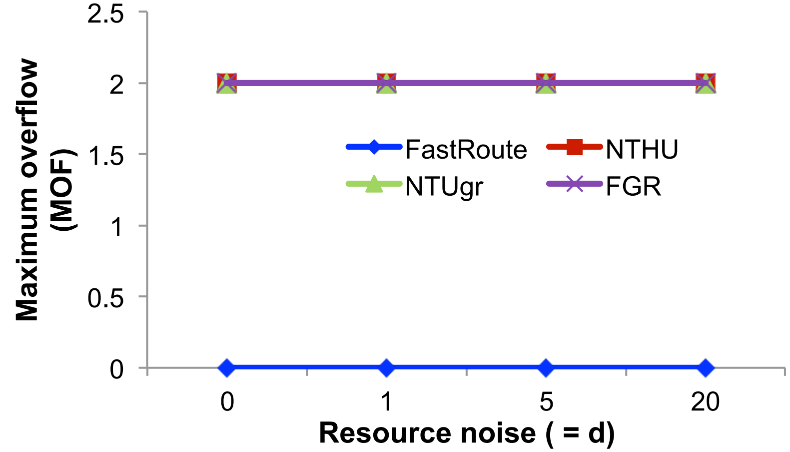
Experiment 2: Resource Noise

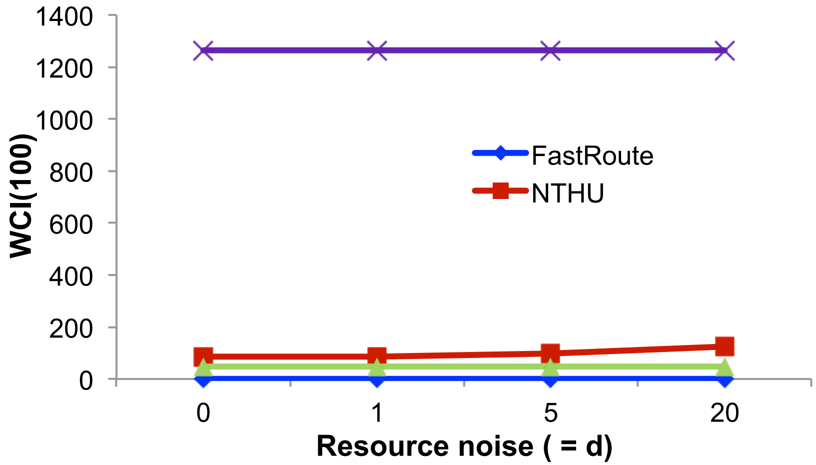
- **Add *d* units to both blockage and capacity to all the gedges**
- **Effective capacity of every gedge is unchanged**
- **Global routing problem should not be different, from router viewpoint**

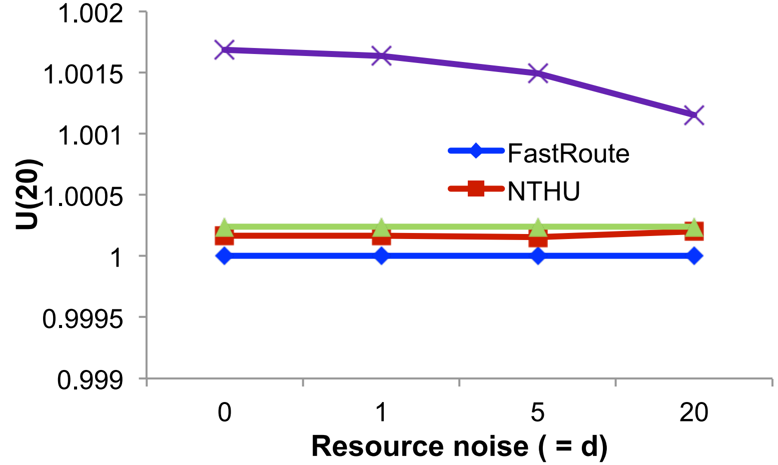


Resource Noise Experimental Results



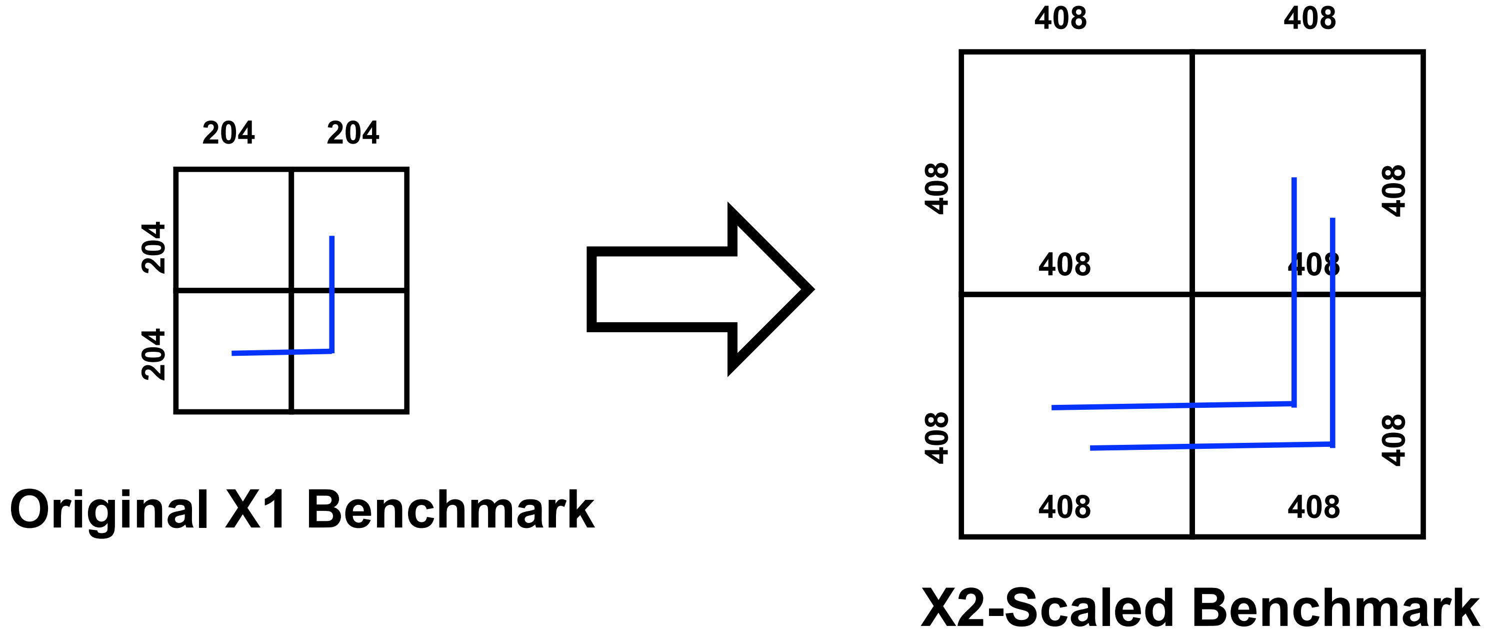




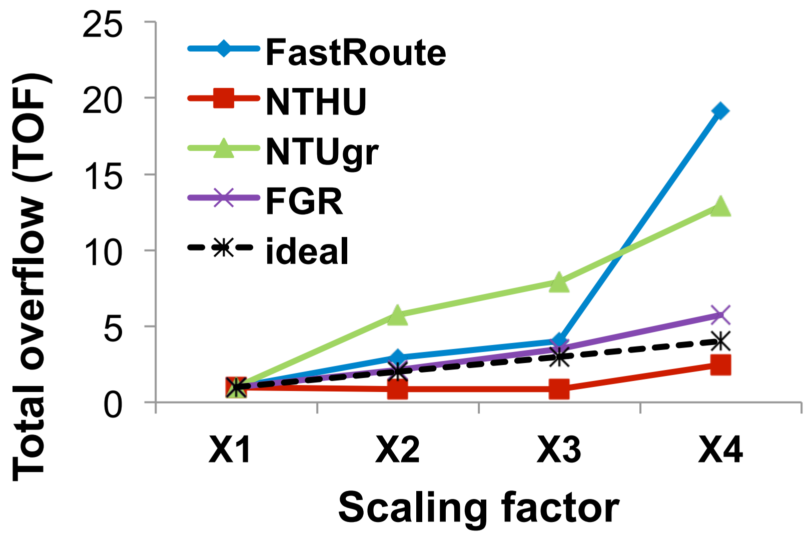


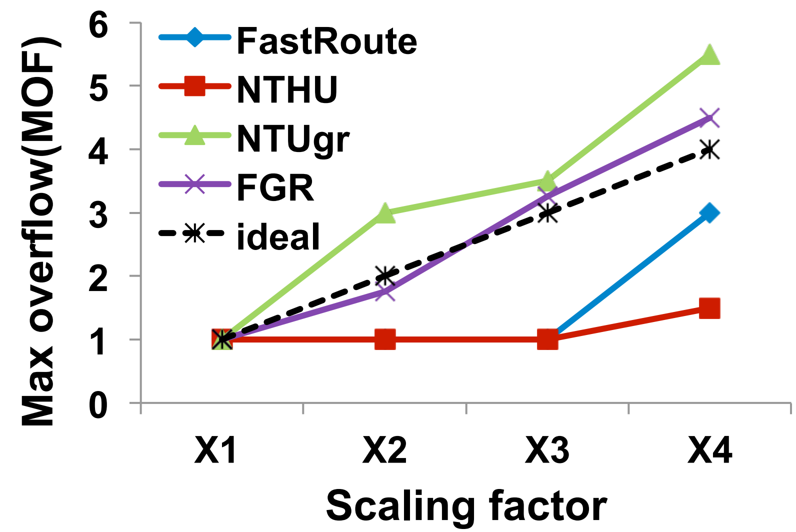
Experiment 3: Instance Scaling

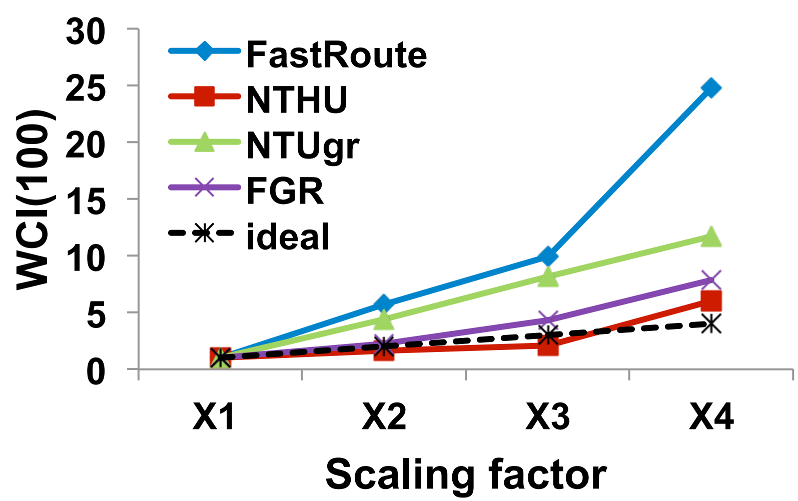
- **Simple scaling of X1 benchmark → X2 benchmark**
  - Duplicate all pins and nets of the original benchmark
  - Double the capacity and blockages of gedges
- **Twice the X1 solution cost is an upper bound on the optimum X2 solution cost**

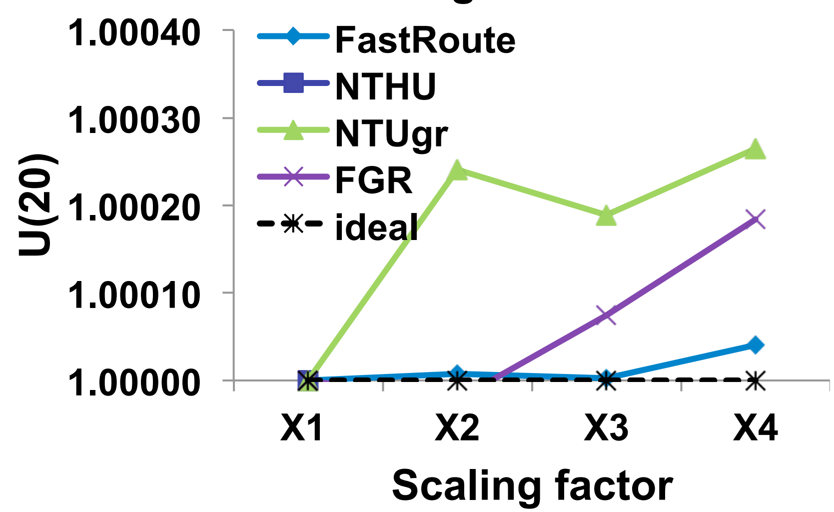


Instance Scaling Experimental Results









Conclusions

- **Study stability and scalability of four global routers**
- **All four routers show room for improvement**
- **Possible reasons leading to instability**
  - **Testcase-specific parameter tuning**
    - **Knobs tuning on one benchmark may lose its advantage on others**
  - **Over-reduction of congestion (reflects ISPD contest metric)**
    - **Unnecessary detours and over-sensitivity**
    - **Routability estimation allows moderate congestion (WL within 10% extension)**
  - **Unstable metrics**
    - *TOF*, *MOF*, *WCI(100)*, *U(20)* **all vary significantly over different gcell definitions**
    - **New metrics with better stability are needed to facilitate future work**

THANK YOU

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Problem Formulation

- **Routing grid modeling**
  - **Decomposition of design area**
  - **Mapping of rectangles into *gcells* (global cells)**
  - **Other parameters**
    - ***gedges* (global edges), gedge capacity , gedge overflow**