A New Prediction-based Routing and Wavelength Assignment Mechanism for Optical Transport Networks

Eva Marín-Tordera, Xavier Masip-Bruin, Sergio Sánchez-López, Josep Solé-Pareta, Jordi Domingo-Pascual

Computer Architecture Department

Technical University of Catalonia (UPC)

Prediction Based Routing

- Usual Routing Algorithms need messages to update TEDs with information about the network state.
- Network state information is not accurate:
  - Aggregating information.
  - Triggering of update messages.
  - Latency associated in flooding of the update messages.
- Routing Algorithms utilise inaccurate state information: Routing Inaccuracy Problem (RIP).

Prediction Based Routing
Idea

- Source nodes can learn which is the best path and wavelength without update messages.

- Dynamic learning according to the routing information obtained in previous connection set-ups. (Based on branch prediction).

Prediction Based Routing
Network state registration

- In Branch Prediction the prediction if a branch instruction will be taken or not is done according to the history of previous outcomes of the branch (not knowing exactly the processor state).
- Analogy with branch prediction: It is necessary to register the history of previous connections set-ups.
- Register of previous set-ups for every ligth-path

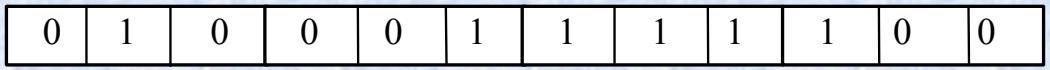
  Wavelength Registers (WR).

Prediction Based Routing
Cycle

- Cycle: Basic unit of time where the history state registers (WRs) are modified.
- One Cycle: Part of the holding time, in our simulations 1 Cycle = 1/10 holding time.
- Time measured in cycles
  - Holding time
  - Arrival time
  - Time between updates (for First-Fit)

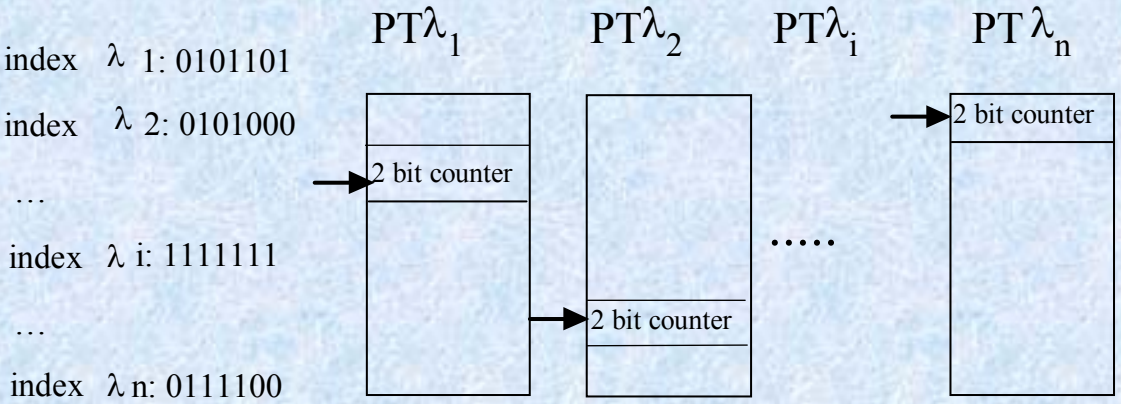
Prediction Based Routing
Wavelength Registers

- There is one WR for every wavelength on a path (ligth-path) for every source-destination pair of nodes.
- Every cycle the WR is filled with a '0' if a traffic request is being sent with this wavelength on that path in that cycle from the source node to the destination node and with a '1' if it is not.
- Example of WR: the value on the right is the newest and the value on the left is the oldest



Prediction Based Routing
Prediction Tables

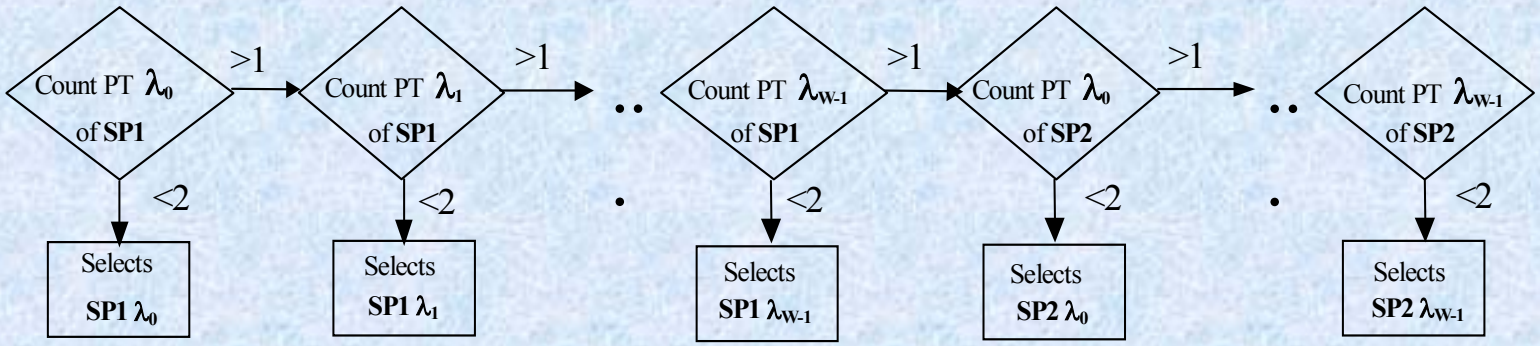
- There is one Prediction Table (PT) for every wavelength on a path (ligth-path) for every source-destination pair of nodes.
- Index to access PT obtained from the corresponding WR.
- Prediction: Read two-bit counter value<2 not blocked, value>1 blocked



2 bit counter	Prediction
00	Not blocked
01	Not blocked
10	Blocked
11	Blocked

Prediction Based Routing
Algorithm

- Two shortest paths, SP1, SP2 and W wavelengths.



- The PBR algorithm checks the counter value of the PT and the availability of the corresponding outgoing link towards that destination.

Prediction Based Routing
Algorithm

- Special case:

  If the PBR algorithm predicts that all wavelengths of SP1 and SP2 are unavailable, it tries to assign route and wavelength based only on the availability information of the outgoing links.

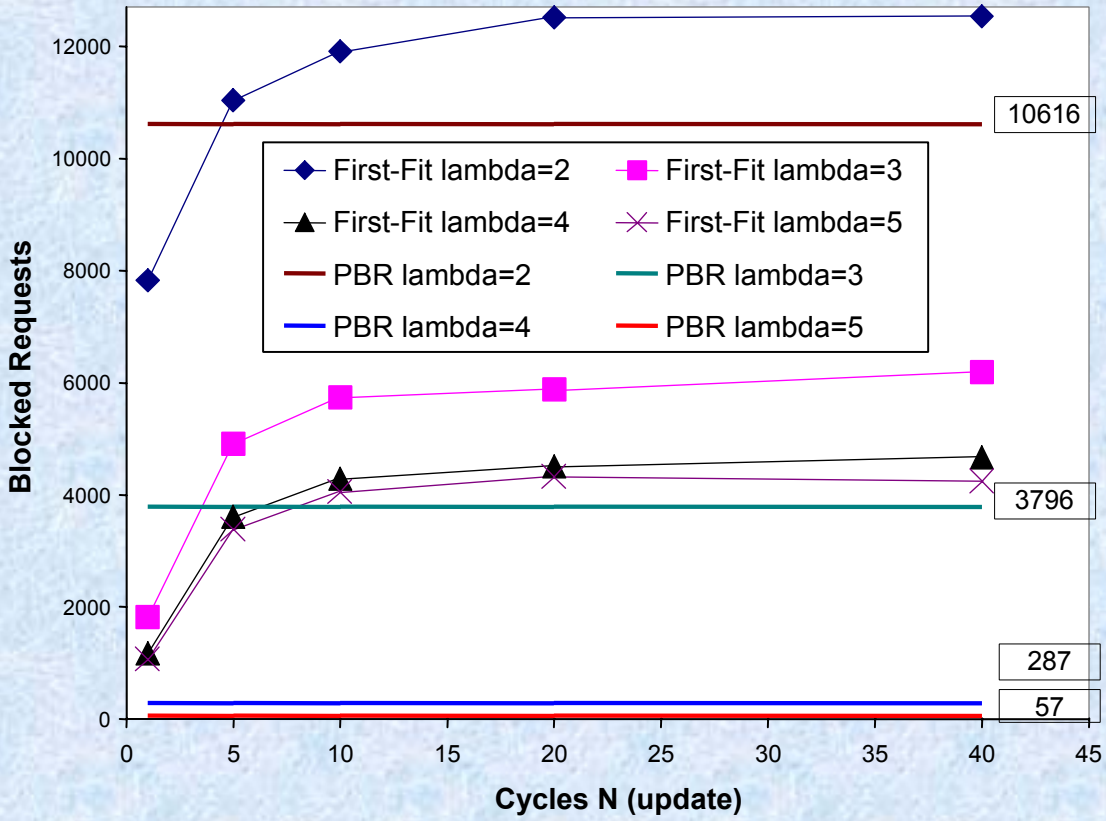
- Updating the PT:

  PT of the selected wavelength and path is updated by increasing the counter if connection request is blocked and decreasing if it is not.

Prediction Based Routing
Evaluation

- Simulations: Comparison between PBR and First-Fit.
- Topology test: 15 nodes (2 sources, 2 destinations) with one-fibre links.
- Connections arrivals (60,000) modeled by Poisson, each one requiring a full wavelength.
- Number of wavelengths variable: 2, 3, 4 and 5
- Number of cycles between update messages for First-Fit variable :1, 5, 10, 20, 40.

Prediction Based Routing
Results



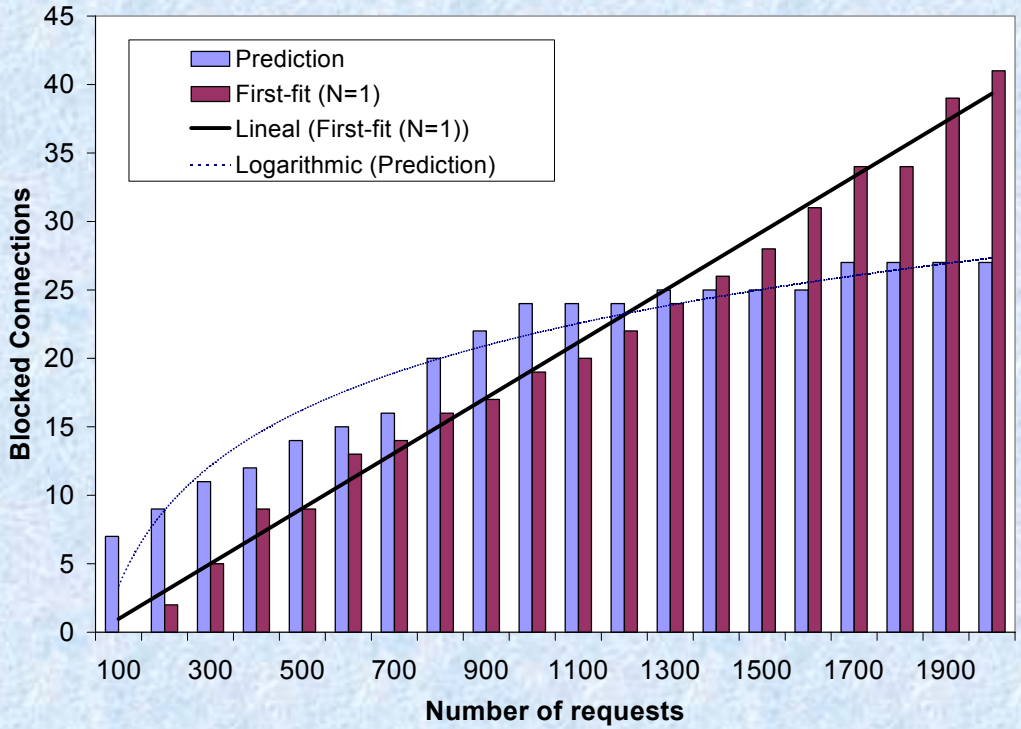
Prediction Based Routing
Results Evaluation

- For 2 and 3 wavelengths First-Fit behaves better than PBR only when the update messages are every cycle (N=1)
- From lambda=4 the PBR always behaves better than the First-Fit⇒ If there are enough wavelengths the PBR assigns better the routes and wavelengths.
- When N=1 and with enough lambdas First-Fit assigns an occupied wavelength because two connections are requested at the two source nodes at the same time. One node assigns with outdated information.

  ⇒ PBR more learning capability than First-Fit

Prediction Based Routing
Results: Learning Capability

Evolution of blocked requests, every new 100 requests, from 0 to 2000 requests for lambda=4 and N=1.



Prediction Based Routing
Conclusions

- The PBR removes the update messages required for the TEDs (only connectivity messages are necessary)

  $\Rightarrow$ Which reduces the signaling overhead.

- In highly dynamic networks the PBR can efficiently change the routing decisions after a training period

  $\Rightarrow$ Due its learning capability.