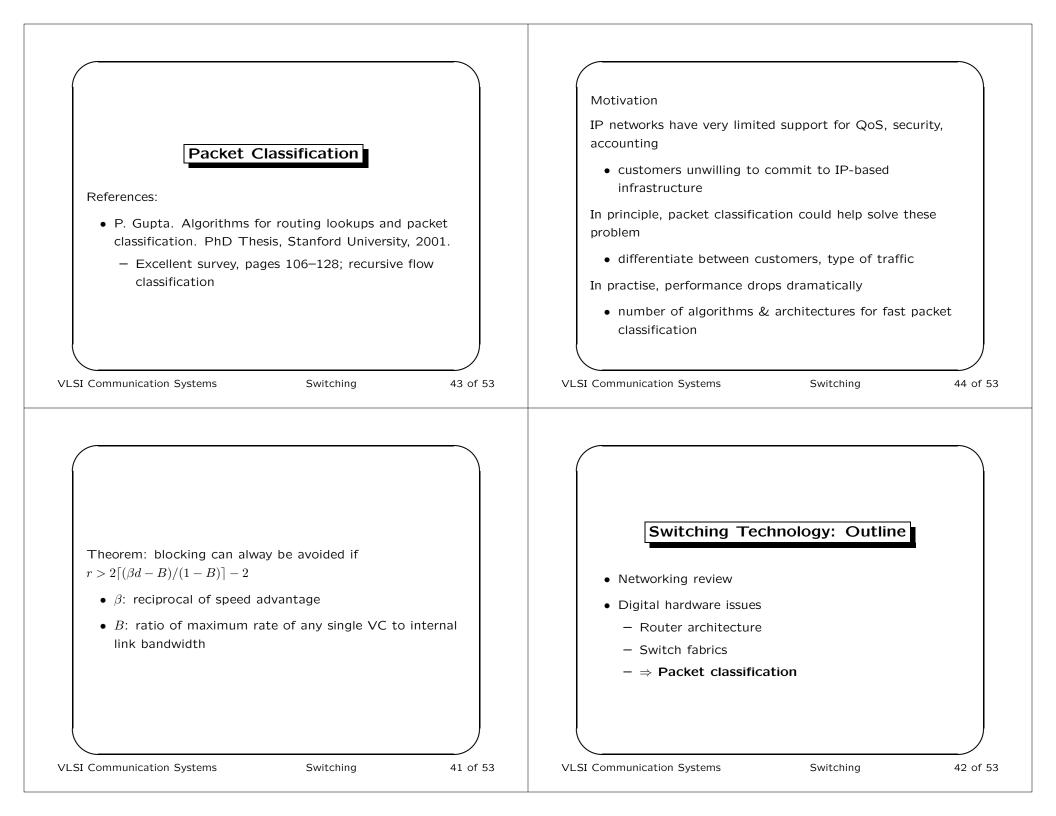
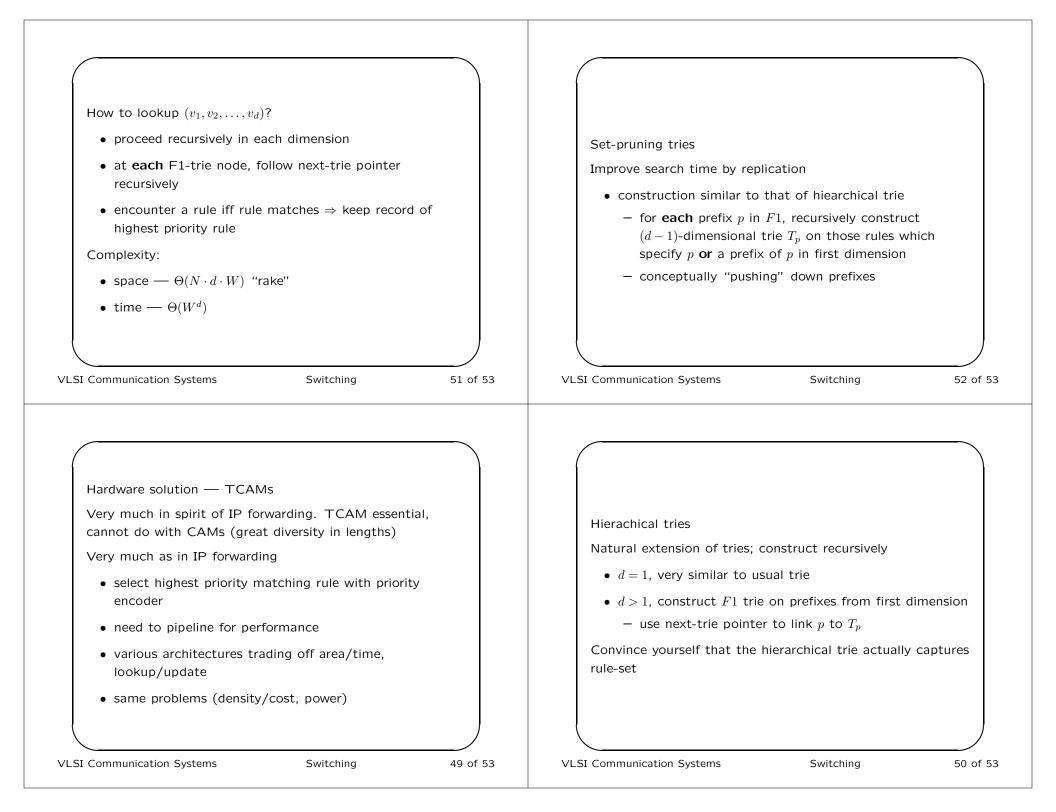


| | Static routing |
|--|--|
| | Statically routed switch — all cells in a VC follow same path |
| | • IPP inserts path specification into the cell headers |
| internal links need not be much faster than line speed Requires a resequencing buffer, since cells can arrive along | can perform static routing with many interconnection topologies, including Benes network |
| different paths | 3-stage Clos network similar to Benes network, except that |
| 1000 ports — resequencing buffer of size 50–100 cells statistically acceptable | switch elements in stage 1 are $d\times r,$ stage 2 are $d\times d,$ and stage 3 are $r\times d$ |
| | when new VC added, control processor must find some path with enough unused bandwidth on each link |
| | - checks r pairs of links |
| | |
| Communication Systems Switching 39 of 53 | VLSI Communication Systems Switching 40 c |
| a Communication Systems Switching 39 of 53 Banyan network Dynamically routed multistage fabric built from 2×2 switches Banyan on 2ⁿ outputs: n stages each with 2ⁿ⁻¹ elements element in <i>i</i>-th stage examines <i>i</i>-th bit of output-id | Benes networks $B_{n,d} - n$ is number of input/output ports, d is number of inputs and outputs of constituent switch elements • recursive construction $n = d$, single $d \times d$ switch element • $n = d^2$ consists of 3 stages with d elements in each stage - first stage distributes incoming cells across all |
| Banyan network Dynamically routed multistage fabric built from 2×2 switches Banyan on 2ⁿ outputs: n stages each with 2ⁿ⁻¹ elements element in <i>i</i>-th stage examines <i>i</i>-th bit of output-id | Benes networks $B_{n,d}$ — n is number of input/output ports, d is number ofinputs and outputs of constituent switch elements• recursive construction $n = d$, single $d \times d$ switch element• $n = d^2$ consists of 3 stages with d elements in eachstage- first stage distributes incoming cells across allswitches in middle to balance load |
| Banyan network Dynamically routed multistage fabric built from 2×2 switches Banyan on 2ⁿ outputs: n stages each with 2ⁿ⁻¹ elements | Benes networks $B_{n,d} - n$ is number of input/output ports, d is number of inputs and outputs of constituent switch elements • recursive construction $n = d$, single $d \times d$ switch element • $n = d^2$ consists of 3 stages with d elements in each stage - first stage distributes incoming cells across all |



| Computational complexity First implementation of firewalls: linear scan, with some tricks • works fine for 3 Mb Ethernet, 10 rules in rule-set Innate complexity: performing classification is akin to searching geometrical structures • recall from IP forwarding: prefix corresponds to interval of $[0, 2^{32} - 1]$ | Given set of N disjoint ranges {[l₁, u₁],, [l_N, u_N]} partitioning [0, 2³² - 1] range lookup problem is to find range corresponding to point P assumption: lots of lookups, can spend time preprocessing set various solutions: binary search on endpoints, prefix matching (convert range to set of prefixes) [4,7] — 01**; Interval [3,8] — 0011, 01**, 1000; Interval [1,14] — 0001, 001*, 01**, 10**, 110*, 1100 worst case: range on W-dimensions becomes 2W - 2 prefixes |
|---|--|
| Communication Systems Switching 47 of 53 | VLSI Communication Systems Switching 48 c |
| Syntax and semantics of rules Will study classification based on header fields | |



Search for (v_1, v_2, \ldots, v_d) by finding longest matching prefix of v_1 , follow its next trie pointer, recurse

• guaranteed every matching rule encountered

Complexity:

- time $\Theta(W \cdot d)$ (no backtrack!)
- space $\Theta(N^d \cdot d \cdot W)$

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