



Algorithms: Design  
and Analysis, Part II

# The Bellman-Ford Algorithm

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Internet Routing

# From Bellman-Ford to Internet Routing

**Note:** The Bellman-Ford algorithm is intuitively “distributed”.

**Toward a routing protocol:**

(1) Switch from source-driven to destination driven

[Just reverse all directions in the Bellman-Ford algorithm]

- Every vertex  $v$  stores shortest-path distance from  $v$  to destination  $t$  and the first hop of a shortest path

[For all relevant destinations  $t$ ]

(“Distance vector protocols”)

# Handling Asynchrony

(2) Can't assume all  $A[i, v]$ 's get computed before all  $A[i - 1, v]$ 's

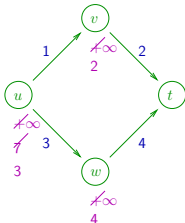
**Fix:** Switch from “pull-based” to “push-based”: As soon as  $A[i, v] < A[i - 1, v]$ ,  $v$  notifies all of its neighbors.

**Fact:** Algorithm guaranteed to converge eventually. (Assuming no negative cycles)

[Reason: Updates strictly decrease sum of shortest-path estimates]

⇒ RIP, RIP2 Internet routing protocols very close to this algorithm  
[see RFC 1058]

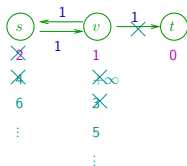
**Example:**



# Handling Failures

**Problem:** Convergence guaranteed only for static networks (not true in practice).

**Counting to Infinity:**



**Fix:** Each  $V$  maintains entire shortest path to  $t$ , not just the next hop.

“Path vector protocol”      “Border Gateway Protocol (BGP)”

**Con:** More space required.

**Pro#1:** More robust to failures.

**Pro#2:** Permits more sophisticated route selection (e.g., if you care about intermediate stops).