Popular Communication Operations

- One-one sending/one-all broadcasting
- All-all broadcasting

- Accumulation (or gather)

- Reduction

  *Initially*: $V_0 \ V_1 \ \ldots \ \ V_{p-1}$

  *Then*: $V_0 \oplus V_1 \oplus \ldots \oplus V_{p-1}$

to all processors.

- One-all personalized communication (single node scatter).
- All to all personalized communication.
Implementation of One-to-All Broadcasting

Store-Forward Routing

\[ \text{Ring} \]

- \( \alpha \) - startup time
- \( \beta \) - transmission speed.

The cost is: \( \frac{p}{2} \times (\alpha + \beta m) \)

**Linear array**: the worst cost is \( p(\alpha + \beta m) \).
Broadcasting on Mesh

MESH

Stage 1

Stage 2

The cost

$$2\sqrt{p}(\alpha + \beta m)$$
Broadcast with wormhole routing

Wormhole routing: fast pipelined message sending between two nodes even they are not directly connected. Node-to-node communication cost \( \approx \alpha + \beta m \) and it does not depend on the node distance (i.e., the number of hops).

**Ring (Linear Array)**

1

2

3

About \( \log p \) steps and there is no message pipeline contention. Total communication cost is about \( \log p(\alpha + \beta m) \).
Implementation of All-to-All Broadcast

RING

Store-Forward

Step 1

Step 2

Total $p - 1$ steps. Thus the cost is $(p - 1)(\alpha + \beta m)$.

Using store-forward is good enough.
One-to-all personalized broadcasting

Broadcasting from the center of a linear array.

- Message size:
  - $\alpha + \frac{p}{2} m\beta$
  - $\alpha + (\frac{p}{2} - 1) m\beta$
  - $\ldots$
  - $\alpha + 1m\beta$

- Total cost $\approx \frac{p}{2} \alpha + \frac{1}{2} (\frac{p}{2})^2 m\beta$.

Broadcast from the left end-point of a linear array.

- $(p - 1)\alpha + \frac{(p-1)^2}{2} m\beta$. 

CS, UCSB Tao Yang