



# **CS4379: Parallel and Concurrent Programming**

## **CS5379: Parallel Processing**

### **Lecture 21**

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# Lecture Video

- Please view the lecture video either from Teams or from the below link:

<https://texastechuniversity.sharepoint.com/sites/CS4379-CS5379/Shared%20Documents/General/Lecture21.mp4>

## Course Info

- **Lecture Time:** TR, 12:30-1:50
- **Lecture Location:** ECE 217
- **Sessions:** CS4379-001, CS4379-002, CS5379-001, CS5379-D01
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- **More info:**
  - <http://www.myweb.ttu.edu/yonchen>
  - <http://discl.cs.ttu.edu>; <http://cac.ttu.edu/>; <http://nsfcac.org>

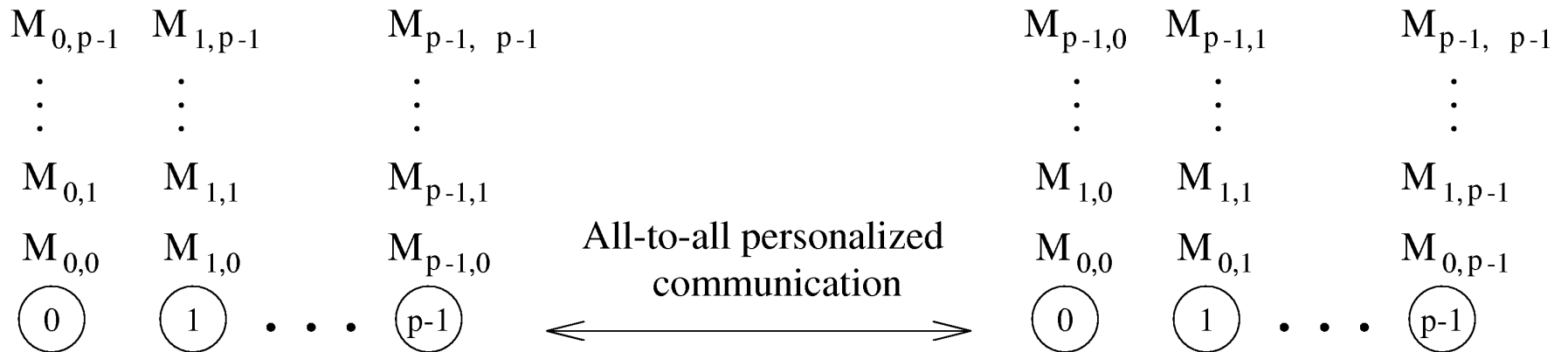
# Outline

- Questions?
- All-to-all scatter/All-to-all personalized communication

# All-to-all Scatter

- Algorithms often require **each processor** to send different data to each of the other processors
- This operation is called an **all-to-all personalized communication or an all-to-all scatter or total exchange**
- At the start of an all-to-all scatter, each processor has  $pm$  words of data; at the end each processor has a copy of the  $m$  words that originated at each of the other processors,  $pm$  words in all
- Naïve all-to-all scatter using  $p$  one-to-all scatters

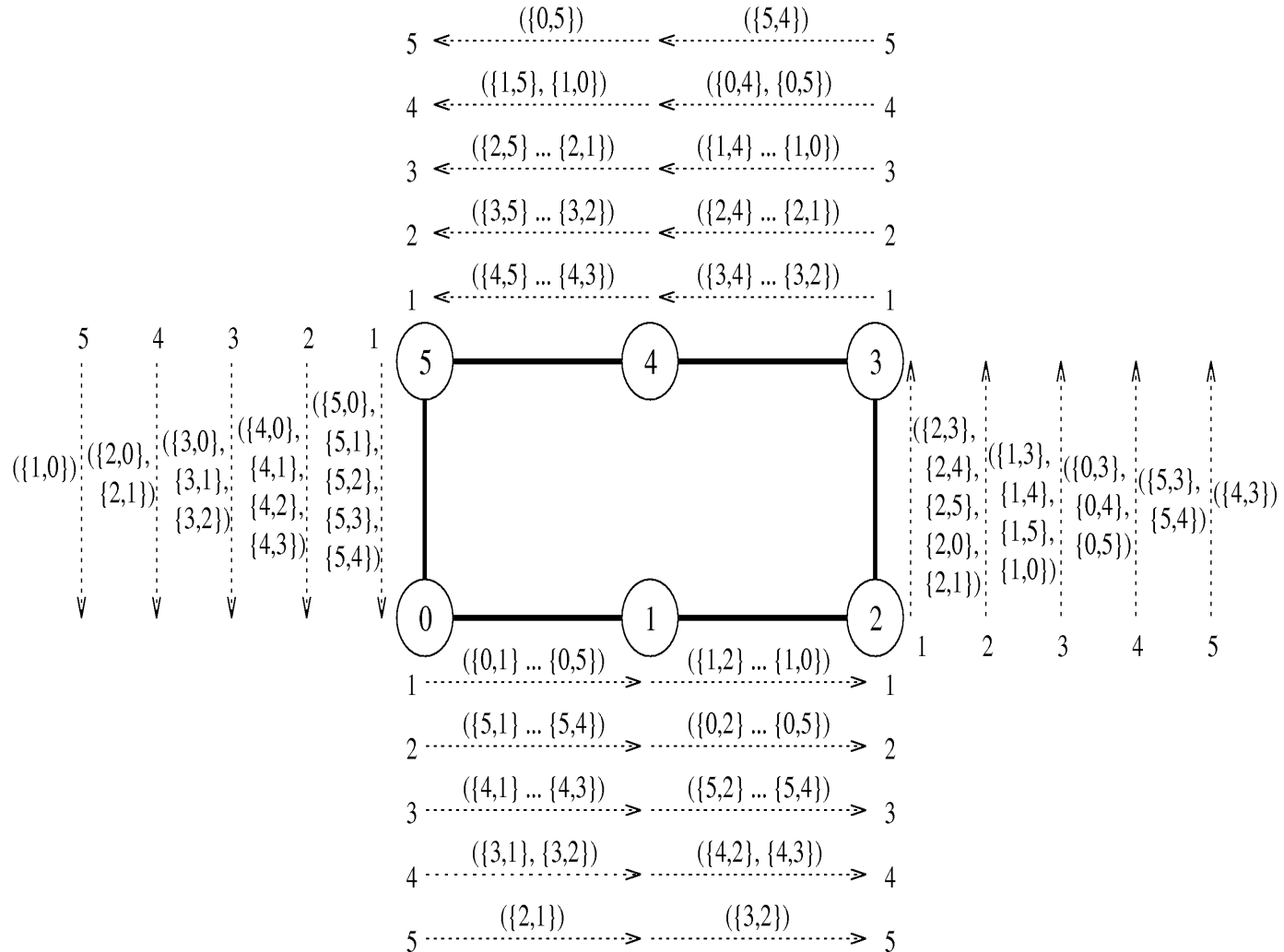
# All-to-all Scatter



## SF Routing on Ring

- Every processor consolidates all the data to be sent and sends a single message to the next processor on the ring in the first step
- In every subsequent step, processors retain part of the message received for themselves and send the rest to the next processor on the ring

# SF Routing on Ring





## SF Routing on Ring

- Steps?

$$(p-1)$$

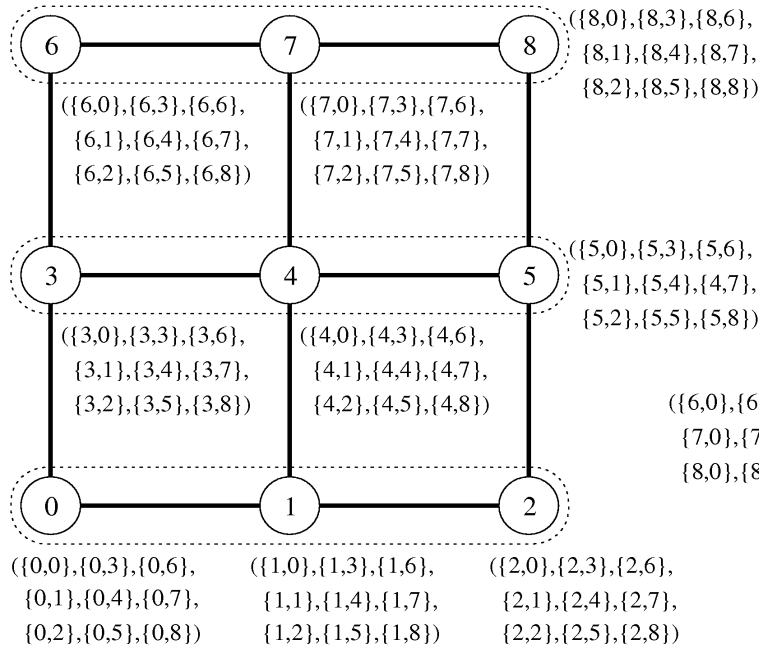
- Cost?

$$\left(t_s + \frac{1}{2}mt_w p + t_h\right)(p-1)$$

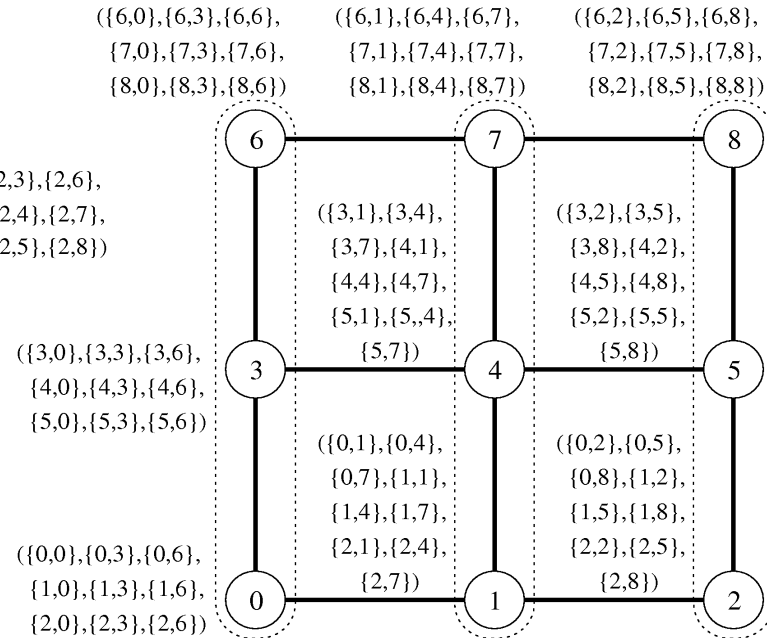
# SF Routing on 2d Torus

- Two-phase algorithm (similar to others for 2d-mesh/torus)
- First phase:
  - Processors consolidate messages into groups meant for each processor column
  - The ring method is applied to each processor row independently
- Second phase:
  - Now the messages in each processor are sorted into groups meant for each processor row
  - The ring method is applied to each processor column independently

# SF Routing on 2d Torus



(a) Data distribution at the beginning of first phase



(b) Data distribution at the beginning of second phase

# SF Routing on 2d Torus

- Steps?

$$2(\sqrt{p} - 1)$$

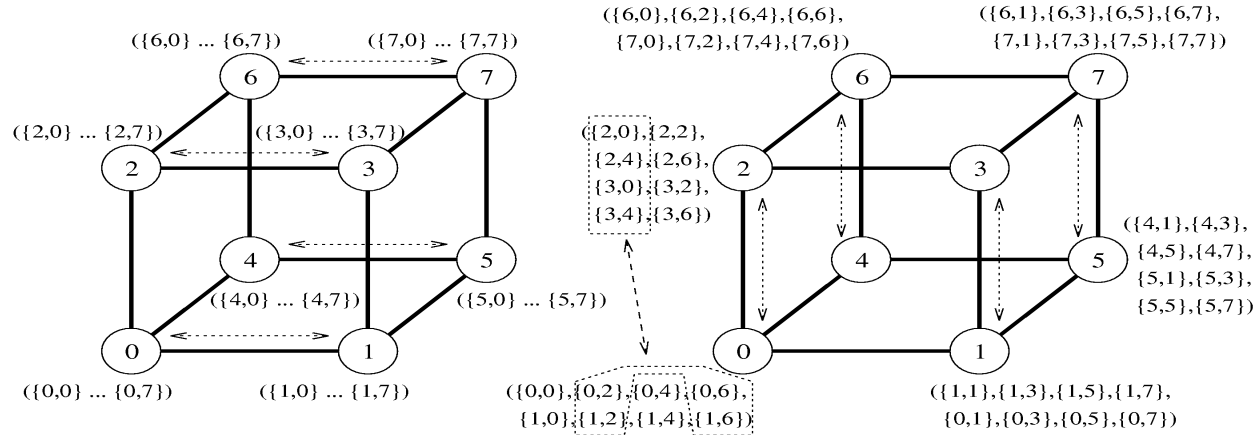
- Cost?

$$(2t_s + t_w mp + 2t_h)(\sqrt{p} - 1)$$

## SF Routing on Hypercube

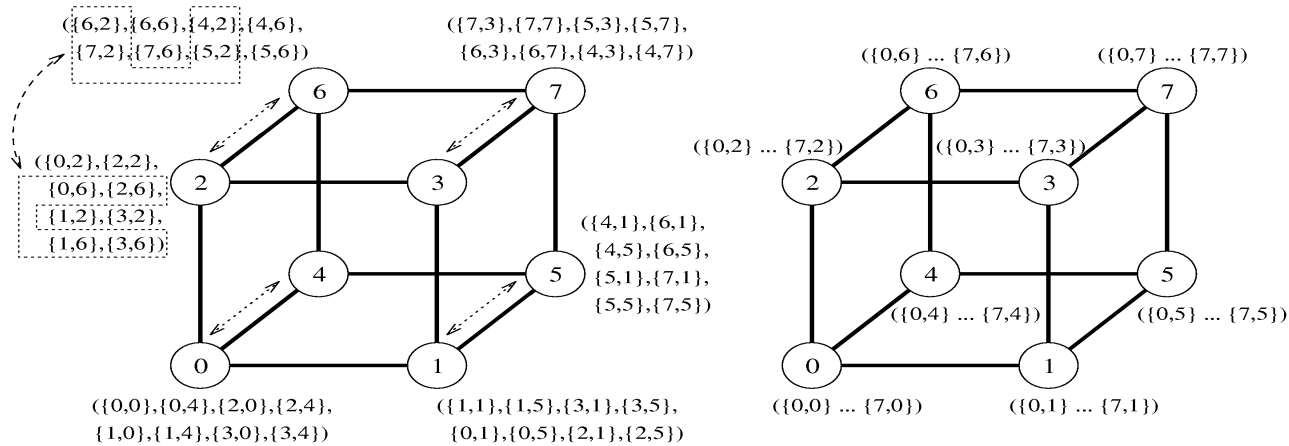
- Take  $\log(p)$  steps for a p processor hypercube
- In the i-th step, every processor exchanges half of messages with the neighboring processor along the i-th dimension (i.e. the processor label differs in the i-th least significant bit)
- At each stage, every processor holds p messages, p/2 of these are consolidated into a single message for exchange with a neighboring processor
- Cost
$$\left(t_s + \frac{1}{2}t_w mp + t_h\right)\log(p)$$

# SF Routing on Hypercube



(a) Initial distribution of messages

(b) Distribution before the second step



(c) Distribution before the third step

(d) Final distribution of messages

## CT Routing

- Cut-through routing performs similarly
- Does not provide benefits over store-and-forward for all-to-all scatters/gathers

# Readings

- Reference book ITPC – Chapter 4, 4.5
- Reference book has algorithm descriptions too



# Questions?

Questions/Suggestions/Comments are always welcome!

Write me: [yong.chen@ttu.edu](mailto:yong.chen@ttu.edu)

Call me: 806-834-0284

See me: ENGCTR 315

*If you write me an email for this class, please start the email subject with [CS4379] or [CS5379].*