Message Switching Layer
Outline

• Network and Router Model
• Basic Concepts
• Basic Switching Techniques
  – circuit-switching
  – packet-switching
  – virtual cut-through switching
  – wormhole switching
• Virtual Channels
• Hybrid Switching Techniques
Network and Router Model

Figure 2.1: Generic router model
Basic Concepts

Figure 2.2: Alternative flow control units in a message

Figure 2.3: An example of asynchronous physical channel flow control
Synchronous Flow Control

Figure 2.4: An example of synchronous physical channel flow control
Basic Switching Techniques

Figure 2.5: View of the network path for computing the no load latency
Figure 2.8: Time space diagram of a packet switched message

\[ t_{packet} = D \times \left( t_r + (t_s + t_w) \times \left\lfloor \frac{L + W}{W} \right\rfloor \right) \]
Circuit Switching

Figure 2.6: Time space diagram of a circuit switched message

\[ t_{\text{circuit}} = t_{\text{setup}} + t_{\text{data}} \quad \text{where} \]
\[ t_{\text{setup}} = D \times (t_r + 2 \times (t_s + t_w)) \]
\[ t_{\text{data}} = \frac{1}{B} \times \left\lceil \frac{L}{W} \right\rceil \]
Virtual Cut-Through Switching

Figure 2.10: Time space diagram of a virtual cut-through switched message

\[ t_{vct} = D \times (t_r + t_s + t_w) + \max(t_s, t_w) \times \left\lceil \frac{L}{W} \right\rceil \]
Wormhole Switching

Figure 2.11: Time space diagram of a wormhole switched message

\[ t_{wormhole} = D \times (t_r + t_s + t_w) + \max(t_s, t_w) \times \left\lfloor \frac{L}{W} \right\rfloor \]
Blocking in Wormhole Network

Figure 2.12: An example of a blocked wormhole switched message
Virtual Channels

Figure 2.17: Virtual channels
Reduced Contention with VC

Figure 2.18: An example of the reduction in header blocking delay by using two virtual channels for each physical channel
Hybrid Switching Techniques

- **Buffered Wormhole Switching**
  - used in IBM SP
  - a packet is divided into 8-flit chunks
  - a central switch buffer can hold chunks if the packet cannot make progress
  - wormhole switching

- **Pipelined Circuit Switching**
  - circuit-switching for setting up path
  - wormhole switching for data transfer

- **Scouting Switching**
  - variation of PCS for fault-tolerant routing