ECS 235B Module 55
Mitigating Covert Channels

Mitigation of Covert Channels

- Problem: these work by varying use of shared resources
- One solution
  - Require processes to say what resources they need before running
  - Provide access to them in a way that no other process can access them
- Cumbersome
  - Includes running (CPU covert channel)
  - Resources stay allocated for lifetime of process

Alternate Approach

- Obscure amount of resources being used
  - Receiver cannot distinguish between what the sender is using and what is added
- How? Two ways:
  - Devote uniform resources to each process
  - Inject randomness into allocation, use of resources

Uniformity

- Variation of isolation
  - Process can't tell if second process using resource
- Example: KVM/370 covert channel via CPU usage
  - Give each VM a time slice of fixed duration
  - Do not allow VM to surrender its CPU time
    - Can no longer send 0 or 1 by modulating CPU usage

Randomness

- Make noise dominate channel
  - Does not close it, but makes it useless
- Example: MLS database
  - Probability of transaction being aborted by user other than sender, receiver approaches 1
    - $q \to 1$
  - $I(A; X) \to 0$
  - How to do this: resolve conflicts by aborting increases q, or have participants abort transactions randomly

Problem: Loss of Efficiency

- Fixed allocation, constraining use
  - Wastes resources
- Increasing probability of aborts
  - Some transactions that will normally commit now fail, requiring more retries
- Policy: is the inefficiency preferable to the covert channel?

Example

- Goal: limit covert timing channels on VAX/VMM
- “Fuzzy time” reduces accuracy of system clocks by generating random clock ticks
  - Random interrupts take any desired distribution
  - System clock updates only after each timer interrupt
  - Kernel rounds time to nearest 0.1 sec before giving it to VM
    - Means it cannot be more accurate than timing of interrupts

Example

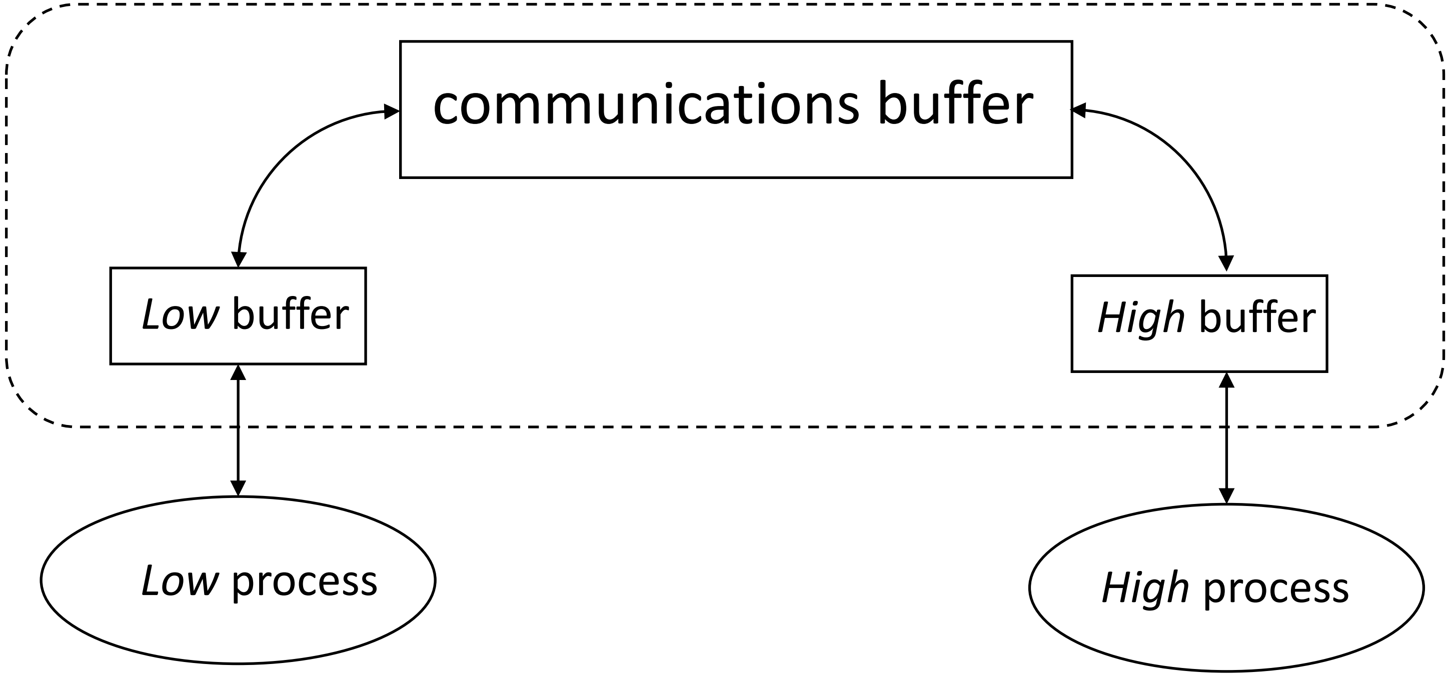
- I/O operations have random delays
- Kernel distinguishes 2 kinds of time:
  - *Event time* (when I/O event occurs)
  - *Notification time* (when VM told I/O event occurred)
    - Random delay between these prevents VM from figuring out when event actually occurred)
    - Delay can be randomly distributed as desired (in security kernel, it’s 1–19ms)
  - Added enough noise to make covert timing channels hard to exploit

Improvement

- Modify scheduler to run processes in increasing order of security level
  - Now we’re worried about “reads up”, so …
- Countermeasures needed only when transition from *dominating* VM to *dominated* VM
  - Add random intervals between quanta for these transitions

The Pump

- Tool for controlling communications path between *High* and *Low*



Details

- Communications buffer of length *n*
  - Means it can hold up to *n* messages
- Messages numbered
- Pump ACKs each message as it is moved from *High* (*Low*) buffer to communications buffer
- If pump crashes, communications buffer preserves messages
  - Processes using pump can recover from crash

Covert Channel

- Low fills communications buffer
  - Send messages to pump until no ACK
  - If *High* wants to send 1, it accepts 1 message from pump; if *High* wants to send 0, it does not
  - If *Low* gets ACK, message moved from *Low* buffer to communications buffer $\Rightarrow$ *High* sent 1
  - If *Low* doesn't get ACK, no message moved $\Rightarrow$ *High* sent 0
- Meaning: if *High* can control rate at which pump passes messages to it, a covert timing channel

Performance vs. Capacity

- Assume *Low* process, pump can process messages more quickly than *High* process
- L_i random variable: time from *Low* sending message to pump to *Low* receiving ACK
- H_i random variable: average time for *High* to ACK each of last *n* messages

Case1: $E(L_i) > H_i$

- *High* can process messages more quickly than *Low* can get ACKs
- Contradicts above assumption
  - Pump must be delaying ACKs
  - *Low* waits for ACK whether or not communications buffer is full
- Covert channel closed
- Not optimal
  - Process may wait to send message even when there is room

Case 2: $E(L_i) < H_i$

- *Low* sending messages faster than *High* can remove them
- Covert channel open
- Optimal performance

Case 3: $E(L_i) = H_i$

- Pump, processes handle messages at same rate
- Covert channel open
  - Bandwidth decreased from optimal case (can’t send messages over covert channel as fast)
- Performance not optimal

Adding Noise

- Shown: adding noise to approximate case 3
  - Covert channel capacity reduced to 1/*nr* where *r* time from *Low* sending message to pump to *Low* receiving ACK when communications buffer not full
  - Conclusion: use of pump substantially reduces capacity of covert channel between *High*, *Low* processes when compared to direct connection