ECE/CS 5780/6780: Embedded System Design

Chris J. Myers

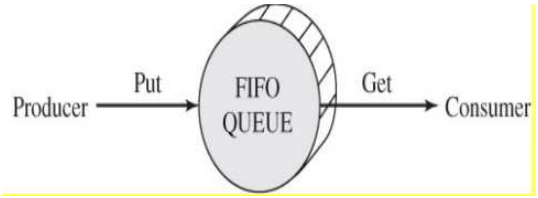
Lecture 8: FIFOs

Producer-Consumer Examples

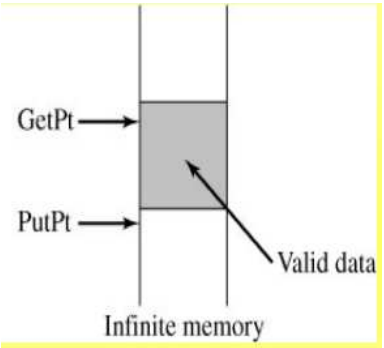
Source/producer	Sink/consumer
Keyboard input	Program that interprets
Program with data	Printer output
Program sends message	Program receives message
Microphone and ADC	Program that saves sound data
Program that has sound data	DAC and speaker

Introduction to FIFOs

- FIFO circular queue is useful for a buffered I/O interface.
- This order-preserving data structure temporarily saves data created by a producer before being processed by a consumer.
- Decouples the producer from the consumer.
- Use statically allocated global memory, so they can be shared by threads, but must be accessed carefully.



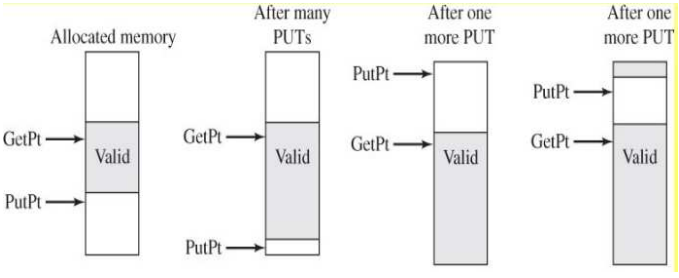
FIFO with Infinite Memory



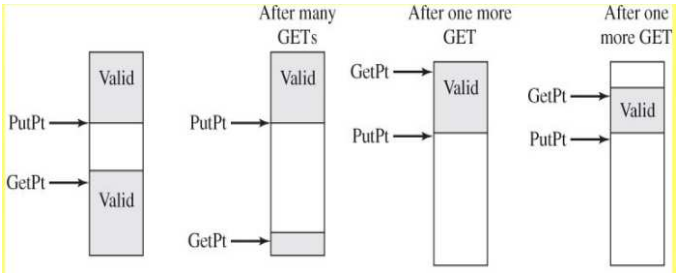
Basic Idea of a FIFO

```
char static volatile *PutPt;  // put next
char static volatile *GetPt;  // get next
// call by value
int Fifo_Put(char data){
  *PutPt = data;    // Put
  PutPt++;          // next
  return(1);        // true if success
}
// call by reference
int Fifo_Get(char *datapt){
  *datapt = *GetPt; // return by reference
  GetPt++;          // next
  return(1);        // true if success
}
```


Two-Pointer FIFO



Two-Pointer FIFO



Initialization of a Two-Pointer FIFO

```
#define FIFOSIZE 10 /* can hold 9 */
char static volatile *PutPt;  /* Pointer to put next */
char static volatile *GetPt;  /* Pointer to get next
           /* FIFO is empty if PutPt=GetPt */
           /* FIFO is full  if PutPt+1=GetPt (with wrap) */
char static Fifo[FIFOSIZE];
void Fifo_Init(void) {
unsigned char SaveSP;
asm tpa
asm staa SaveSP
asm sei                 /* make atomic, entering critical */
  PutPt=GetPt=&Fifo[0]; /* Empty when PutPt=GetPt */
asm ldaa SaveSP
asm tap                 /* end critical section */
}
```


Put for a Two-Pointer FIFO

```
int Fifo_Put(char data) { char *Ppt; /* Temp put pointer */
unsigned char SaveSP;
asm tpa
asm staa SaveSP
asm sei          /* make atomic, entering critical */
  Ppt=PutPt;     /* Copy of put pointer */
  *(Ppt++)=data; /* Try to put data into fifo */
  if (Ppt == &Fifo[FIFOSIZE]) Ppt = &Fifo[0];  /* Wrap */
  if (Ppt == GetPt ) {
asm ldaa SaveSP
asm tap          /* end critical section */
    return(0);   /* Failed, fifo was full */
  } else {
    PutPt=Ppt;
asm(" ldaa %SaveSP\n tap"); /* end critical section */
    return(1); }}           /* Successful */
```


Get for a Two-Pointer FIFO

```
int Fifo_Get(char *datapt) {
unsigned char SaveSP;
  if (PutPt == GetPt ) {
    return(0);   /* Empty if PutPt=GetPt */
  } else {
asm tpa
asm staa SaveSP
asm sei          /* make atomic, entering critical */
    *datapt=*(GetPt++);
    if (GetPt == &Fifo[FIFOSIZE])
      GetPt = &Fifo[0];     /* Wrap */
asm ldaa SaveSP
asm tap          /* end critical section */
    return(1); }}
```


Initialization of a Two-Pointer/Counter FIFO

```
#define FIFOSIZE 10  /* can hold 10 */
char static volatile *PutPt; /* Pointer to put next */
char static volatile *GetPt; /* Pointer to get next */
char Fifo[FIFOSIZE];
unsigned char Size;     /* Number of elements */
void Fifo_Init(void) {
unsigned char SaveSP;
asm tpa
asm staa SaveSP
asm sei                 /* make atomic, entering critical */
  PutPt=GetPt=&Fifo[0]; /* Empty when Size==0 */
  Size=0;
asm ldaa SaveSP
asm tap                 /* end critical section */
}
```


Put for a Two-Pointer/Counter FIFO

```
int Fifo_Put(char data) {
unsigned char SaveSP;
  if (Size == FIFOSIZE ) {
    return(0);       /* Failed, fifo was full */
  } else {
asm tpa
asm staa SaveSP
asm sei              /* make atomic, entering critical */
    Size++;
    *(PutPt++)=data; /* put data into fifo */
    if (PutPt == &Fifo[FIFOSIZE])
      PutPt = &Fifo[0]; /* Wrap */
asm ldaa SaveSP
asm tap              /* end critical section */
    return(1);      /* Successful */
  }
}
```

Get for a Two-Pointer/Counter FIFO

```
int Fifo_Get (char *datapt) {
unsigned char SaveSP;
  if (Size == 0 ){
    return(0);   /* Empty if Size=0 */
  } else {
asm tpa
asm staa SaveSP
asm sei         /* make atomic, entering critical */
    *datapt=*(GetPt++);
    Size--;
    if (GetPt == &Fifo[FIFOSIZE])
      GetPt = &Fifo[0];     /* Wrap */
asm ldaa SaveSP
asm tap         /* end critical section */
    return(1); }}
```


FIFO Dynamics

- Rates of production/consumption vary dynamically.
- t_p is time between `Put` calls, r_p is arrival rate ($r_p = \frac{1}{t_p}$).
- t_g is time between `Get` calls, r_g is service rate ($r_g = \frac{1}{t_g}$).
- If min $t_p \geq$ max t_g, FIFO is not necessary.
- If arrival rate can temporarily increase or service rate temporarily decrease, then a FIFO is necessary.
- If average production rate exceeds average consumption rate (i.e., $\bar{r}_p > \bar{r}_g$), then FIFO will overflow.
- A full error is serious because ignored data is lost.
- An empty error is usually not serious.

SCI Data Flow Graph with Two FIFOs