



SNS COLLEGE OF ENGINEERING (Autonomous)



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

UNIT III

EMBEDDED PROGRAMMING

1.Components for Embedded Program

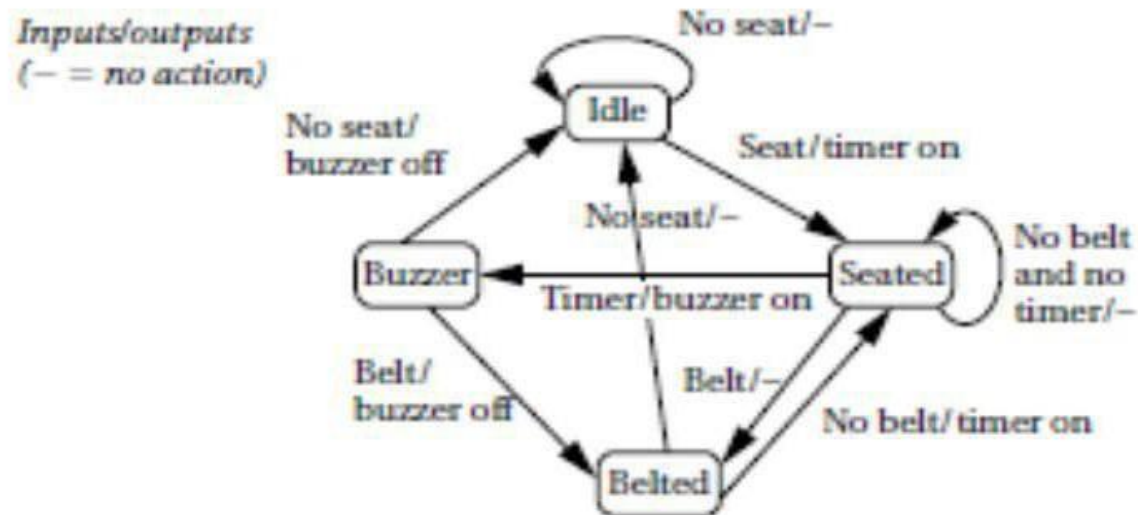
In this section, we consider code for three structures or components that are commonly used in embedded software: the state machine, the circular buffer, and the queue. State machines are well suited to **reactive systems** such as user interfaces; circular buffers and queues are useful in digital signal processing

State Machines

- ❖ When inputs appear intermittently rather than as periodic samples, it is often convenient to think of the system as reacting to those inputs.
- ❖ The reaction of most systems can be characterized in terms of the input received and the current state of the system. This leads naturally to a **finite-state machine** style of describing the reactive system's behaviour.
- ❖ Moreover, if the behaviour is specified in that way, it is natural to write the program implementing that behaviour in a state machine style

- ❖ The state machine style of programming is also an efficient implementation of such computations. Finite-state machines are usually first encountered in the context of hardware design.

A software state machine





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- ❖ A state machine is any object that behaves different based on its history and current inputs. Many embedded systems consist of a collection of state machines at various levels of the electronics or software.
- ❖ In general, a state machine is any device that stores the status of something at a given time and can operate on input to change the status and/or cause an action or output to take place for any given change.
- ❖ In practice, however, state machines are used to develop and describe specific device or program interactions.
 - A set of states.
 - A set of input events.
 - A set of output events.
 - An initial state or record of something stored somewhere.
 - A set of actions or output events that maps the states and input to output.
 - A set of actions or output events that maps the states and inputs to states (which is called a state transition).



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- ❖ Finite State Automaton (FSA), Finite State Machine (FSM) or State Transition Diagram (STD) is a formal method used in the specification and design of wide range of embedded and real time systems. The system in this case would be represented by a finite number of states.
- ❖ Controllers job is to turn on a buzzer if a person sits in a seat and does not fasten the seat belt within a fixed amount of time. This system has three inputs and one output.
- ❖ The inputs are a sensor for the seat to know when a person has sat down, a seat belt sensor that tells when the belt is fastened and a timer that goes off when the required time interval has elapsed. The output is the buzzer.
- ❖ The idle state is in force when there is no person in the seat. When the person sits down, the machine goes into the seated state and turns on the timer.
- ❖ If the timer goes off before the seat belt is fastened, the machine goes into the buzzer state. If the seat belt goes on first, it enters the belted state. When the person leaves the seat, the machine goes back to idle.

Stream-Oriented Programming and Circular Buffers

- ❖ The data stream style makes sense for data that comes in regularly and must be processed on the fly. For each sample, the filter must emit one output that depends on the values of the last n inputs
- ❖ In a typical workstation application, we would process the samples over a given interval by reading them all in from a file and then computing the results all at once in a batch process. In an embedded system we must not only emit outputs in real time, but we must also do so using a minimum amount of memory.

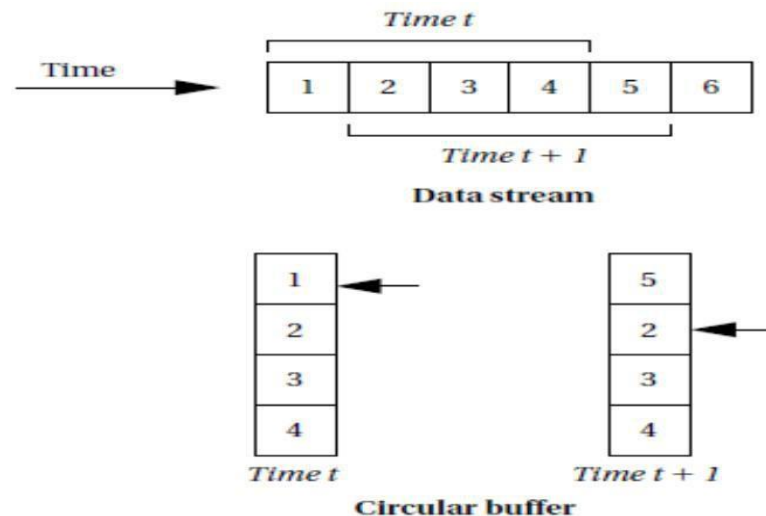


Fig. A circular buffer for streaming data



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- ❖ The circular buffer is a data structure that lets us handle streaming data in an efficient way. Figure illustrates how a circular buffer stores a subset of the data stream. At each point in time, the algorithm needs a subset of the data stream that forms a window into the stream.
- ❖ The window slides with time as we throw out old values no longer needed and add new values. Since the size of the window does not change, we can use a fixed-size buffer to hold the current data.
- ❖ To avoid constantly copying data within the buffer, we will move the head of the buffer in time. The buffer points to the location at which the next sample will be placed; every time we add a sample, we automatically overwrite the oldest sample, which is the one that needs to be thrown out. When the pointer gets to the end of the buffer, it wraps around to the top.



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- ❖ A circular buffer, circular queue, cyclic buffer or ring buffer is a data structure that uses a single, fixed-size buffer as if it were connected end to-end. This structure lends itself easily to buffering data streams.
- ❖ The circular buffer behaviour is ideal for implementing any data structure that is statically allocated and behaves like FIFO.
- ❖ Circular buffers are a special type of buffer where the data is circulated around a buffer. In this way they are similar to a single buffer that moves the next data pointer to the start of the buffer to access the next data. In this way the address pointer circulates around the addresses.
- ❖ When a buffer underruns, it indicates that there is no more data in the buffer and that further processing should be stopped. This may indicate an error if the system is designed so that it would never run out of data.
- ❖ If it can happen in normal operation then the data underrun signal indicates a state and not an error. In both cases, a signal is needed to recognise this point.



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Queues

- ❖ Queues are also used in signal processing and event processing. Queues are used whenever data may arrive and depart at somewhat unpredictable times or when variable amounts of data may arrive. A queue is often referred to as an *elastic buffer*.
- ❖ An elastic buffer is a device that helps smooth the data transfer between two similar, but unsynchronized clock domains.
- ❖ One way to build a queue is with a linked list. This approach allows the queue to grow to an arbitrary size. But in many applications we are unwilling to pay the price of dynamically allocating memory.
- ❖ Linked list is used for building queue.



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For designing the queue, it is declares as follows :

```
# # define Q_SIZE 32  
define Q_MAX (Q_SIZE-1)  
int q[Q_SIZE]; /* array for queue  
int head, tail; /* position of head and tail in the queue
```



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Thank you