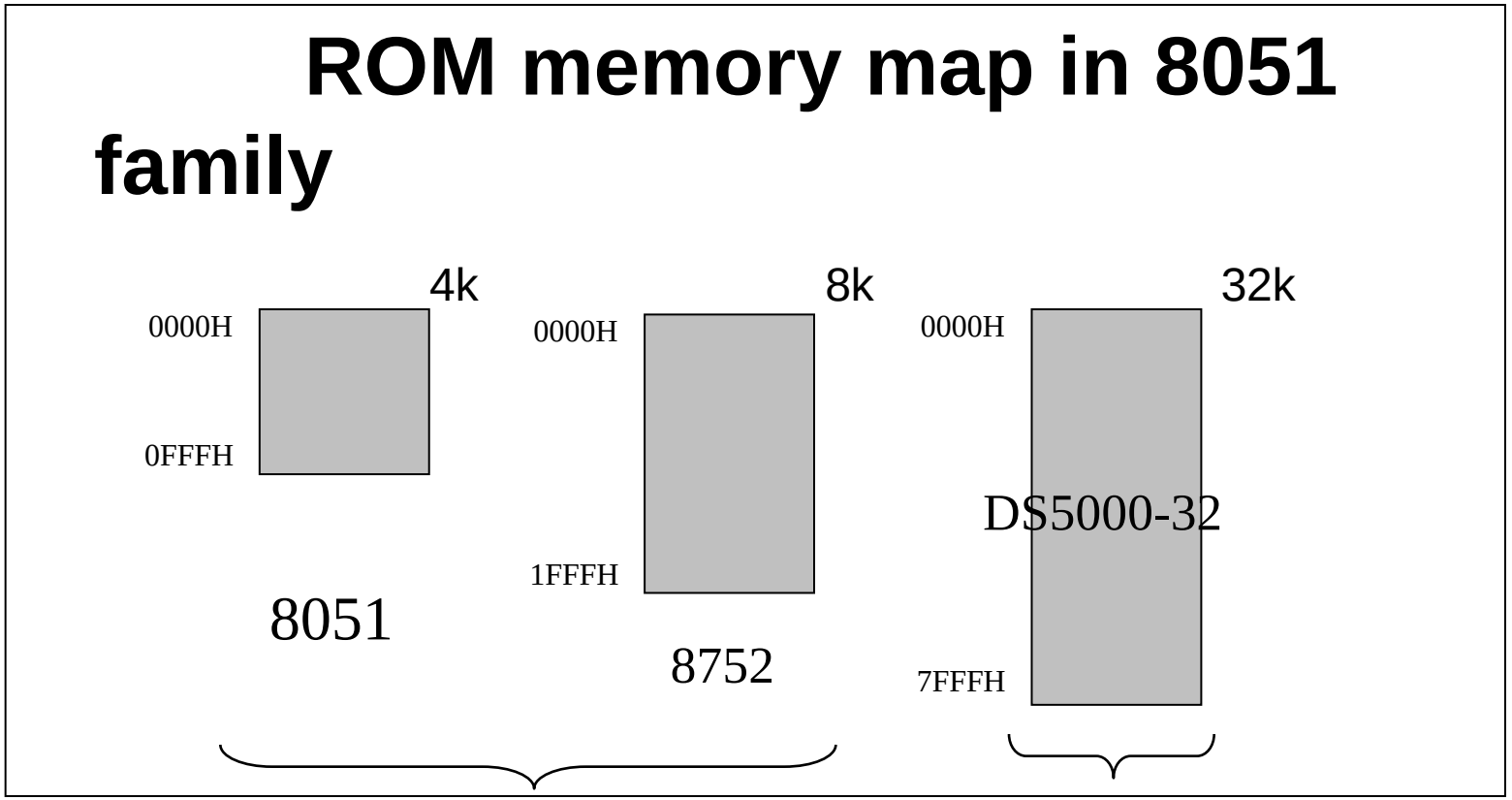
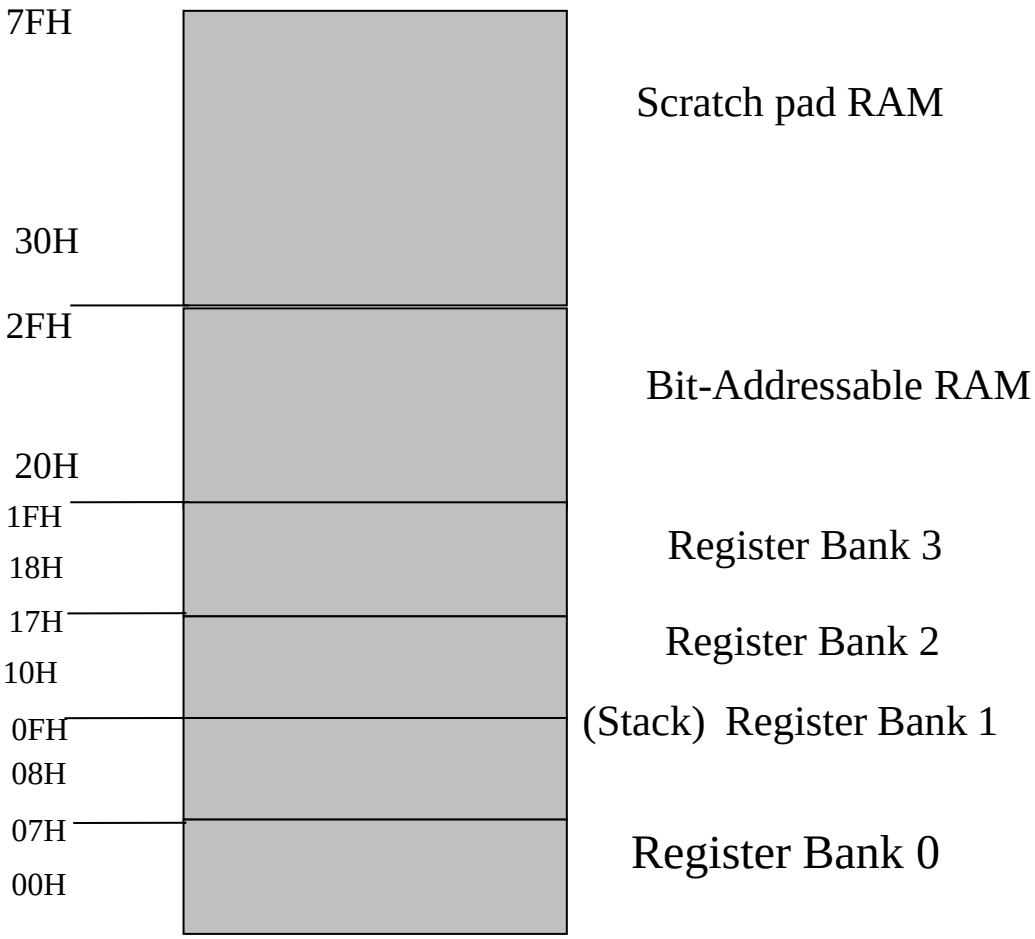
8051 Microcontroller memory Organization and its Applications

Memory mapping in 8051



RAM memory space allocation in the 8051



Timers /Counters

The 8051 has 2 timers/counters:

- Timer/Counter 0
- Timer/Counter 1

Timer :

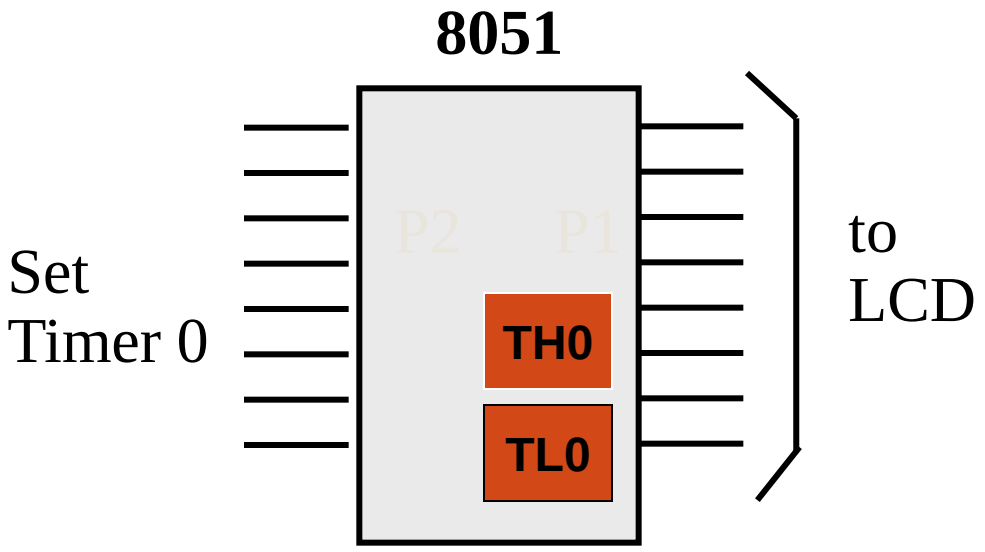
- Used as a time delay generator.
- Many microcontroller application requires the counting of external events such as frequency, time delay.

Registers Used in Timer/Counter

- 8051 has two 16-bit Timer registers ,Timer 0 & Timer 1.
- As 8051 has 8-bit architecture , each Timer register is treated as two 8-bit registers namely TH0, TL0, TH1, TL1.
- One 8-bit mode register -TMOD.
- One 8-bit control register-TCON.

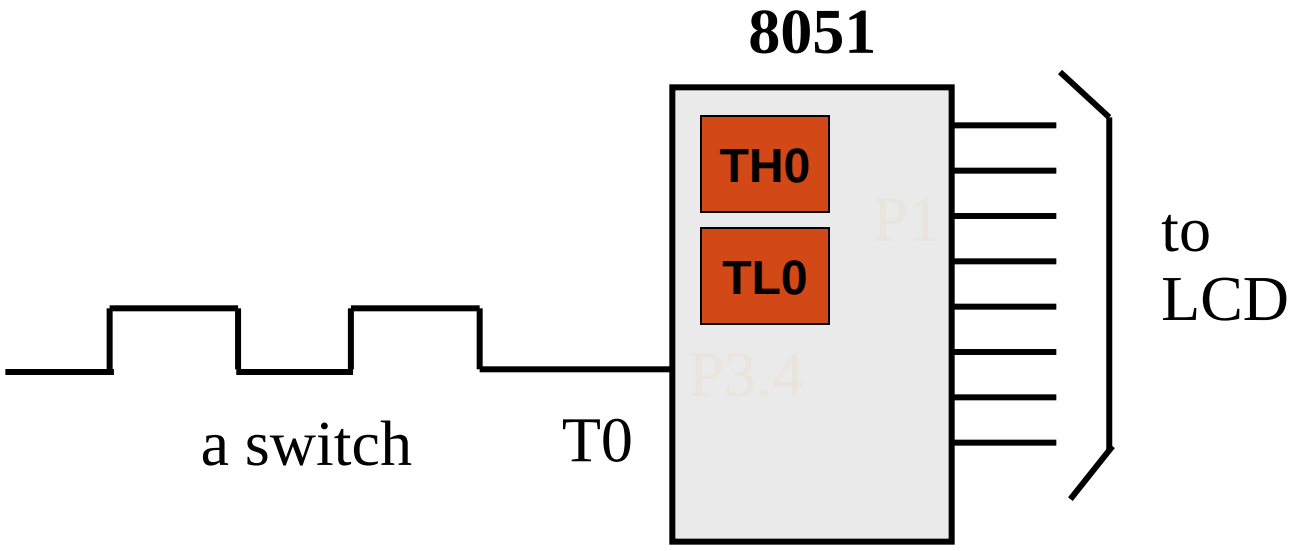
Timer

- Set the initial value of registers
- Start the timer and then the 8051 counts up.
- Input from internal system clock (machine cycle)
- When the registers equal to 0 and the 8051 sets a bit to denote time out

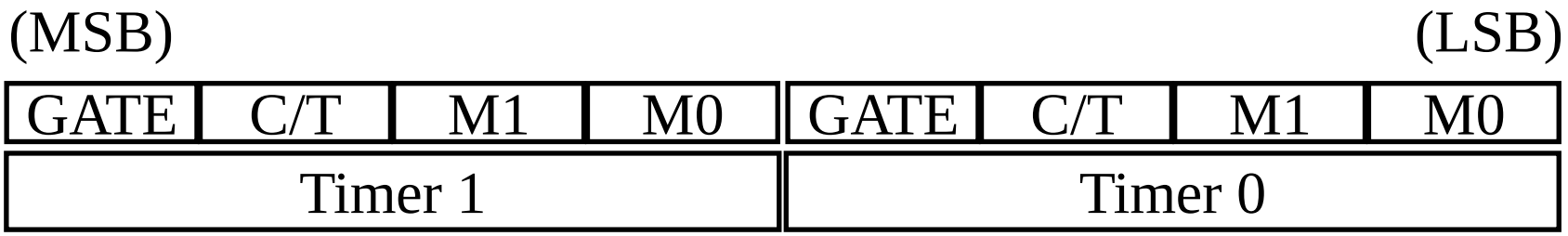


Counter

- Count the number of events
  - Show the number of events on registers
  - External input from T0 input pin (P3.4) for Counter 0
  - External input from T1 input pin (P3.5) for Counter 1
  - External input from Tx input pin.
  - We use Tx to denote T0 or T1.



TMOD Register



- Both Timer 0 &Timer 1 use the same Mode register TMOD.
- It is an-8-bit register .
- The lower 4-bits are meant for Timer 0 &the upper 4-bits are meant for Timer 1
- It is used similar to any other register of 8051 .

C/T : Timer or counter selected cleared for timer operation (input from internal system clock).

Set for counter operation (input from Tx input pin).

M1,M0 : Used for mode selection. Because the Timers of 8051 can be set in 4-different modes.

M1	M0	Mode	Operation
0	0	**0**	1**3-bit timer** mode 8-bit THx + 5-bit TLx
0	1	1	**16-bit timer** mode 8-bit THx + 8-bit TLx
1	0	**2**	**8-bit auto reload** THx holds a value which is to be reloaded into TLx each time it overflows.
1	1	**3**	Split timer mode

Gate

- Every timer has a mean of starting and stopping.

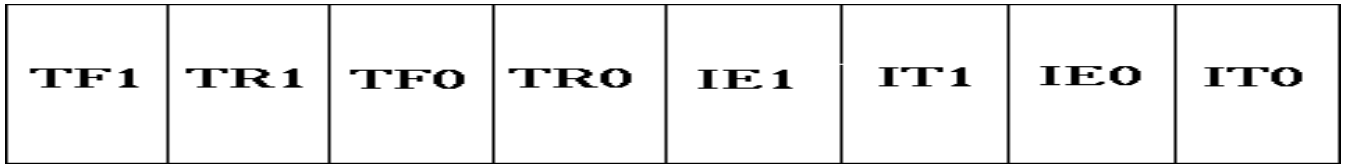
  GATE=0

  - **Internal** control
  - The start and stop of the timer are controlled by way of **software.**

  GATE=1

  - **External** control
  - The hardware way of starting and stopping the timer by **software** and **an external source**.
  - Timer/counter is enabled only while the INT pin is high and the TR control pin is set (TR).

TCON Register



Timer control register TMOD is a 8-bit register which is bit addressable and in which Upper nibble is for timer/counter,

lower nibble is for interrupts

Tcon contd…

- **TR** (Timer run control bit)
  - TR0 for Timer/counter 0; TR1 for Timer/counter 1.
  - TR is set by programmer to turn timer/counter on/off.
    - TR=0 : off (stop)
    - TR=1 : on (start)

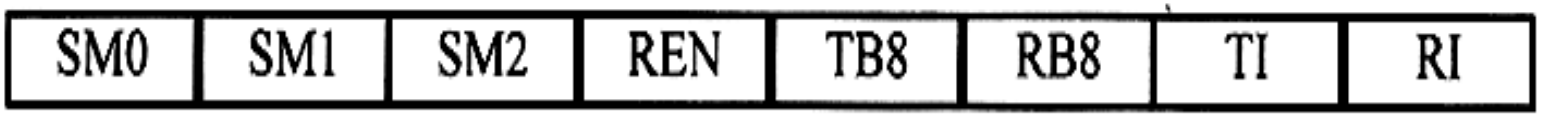
- **TF** (timer flag, control flag)
  - TF0 for timer/counter 0; TF1 for timer/counter 1.
  - TF is like a carry. Originally, TF=0. When TH-TL roll over to 0000 from FFFFH, the TF is set to 1.
    - TF=0 : not reach
    - TF=1: reach
    - If we enable interrupt, TF=1 will trigger ISR.

8051- SERIAL COMMUNICATION

RxD and TxD pins in the 8051

- The 8051 has two pins for transferring and receiving data by
  serial communication. These two pins are part of the
  Port3(P3.0 &P3.1)
- These pins are TTL compatible and hence they require a line
  driver to make them RS232 compatible
- Max232 chip is one such line driver in use.
- Serial communication is controlled by an 8-bit register called
  SCON register, it is a bit addressable register.

SCON (Serial control) register



SM0	SCON.7	Serial port mode specifier
SM1	SCON.6	Serial port mode specifier
SM2	SCON.5	Used for multiprocessor communication. (Make it 0)
REN	SCON.4	Set/cleared by software to enable/disable reception.
TB8	SCON.3	Not widely used.
RB8	SCON.2	Not widely used.
TI	SCON.1	Transmit interrupt flag. Set by hardware at the beginning of the stop bit in mode 1. Must be cleared by software.
RI	SCON.0	Receive interrupt flag. Set by hardware halfway through the stop bit time in mode 1. Must be cleared by software.

SM0 , SM1

These two bits of SCON register determine the framing of data

by specifying the number of bits per character and start bit and stop bits.

There are 4 serial modes.

SM0	SM1	
0	0	Serial Mode 0
0	1	Serial Mode 1, 8 bit data, 1 stop bit, 1 start bit
1	0	Serial Mode 2
1	1	Serial Mode 3

REN, TI, RI

- REN (Receive Enable) also referred as SCON.4.
- When it is high, it allows the 8051 to receive data on the RxD pin. So to receive and transfer data REN must be set to 1.
- When REN=0,the receiver is disabled.

TI,RI Contd…

TI (Transmit interrupt)

- It is the D1 bit of SCON register.
- When 8051 finishes the transfer of 8-bit character, it raises the TI flag to indicate that it is ready to transfer another byte.
- The TI bit is raised at the beginning of the stop bit.

RI (Receive interrupt)

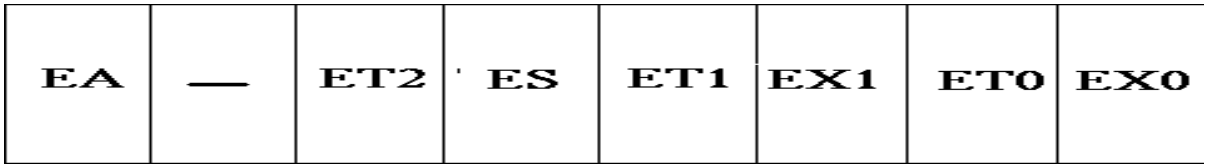
- It is the D0 bit of the SCON register.
- When the 8051 receives data serially ,via RxD, it gets rid of the start and stop bits and places the byte in the SBUF register.
- Then it raises the RI flag bit to indicate that a byte has been received and should be picked up before it is lost.
- RI is raised halfway through the stop bit.

Interrupt Sources

8051 has 6 sources of interrupts

- Reset
- Timer 0 overflow
- Timer 1 overflow
- External Interrupt 0
- External Interrupt 1
- Serial Port events (buffer full, buffer empty, etc)

Interrupt Enable Register



- Upon reset all Interrupts are disabled and do not respond to the Microcontroller
- These interrupts must be enabled by software in order for the Microcontroller to respond to them.
- This is done by an 8-bit register called Interrupt Enable Register (IE).

EA	—	ET2	ES	ET1	EX1	ET0	EX0

- EA : Global enable/disable.
- --- : Undefined.
- ET2 : Enable Timer 2 interrupt.
- ES : Enable Serial port interrupt.
- ET1 : Enable Timer 1 interrupt.
- EX1 : Enable External 1 interrupt.
- ET0 : Enable Timer 0 interrupt.
- EX0 : Enable External 0 interrupt.

Interrupt Priorities

- If two interrupt sources interrupt at the same time ,the interrupt with the highest PRIORITY gets serviced first.

- All interrupts have a power on default priority order.
  1. External interrupt 0 (INT0)
  2. Timer interrupt0 (TF0)
  3. External interrupt 1 (INT1)
  4. Timer interrupt1 (TF1)
  5. Serial communication (RI+TI)

- Priority can also be set to “high” or “low” by IP reg.

Interrupt Priorities (IP) Register

---	---	PT2	PS	PT1	PX1	PT0	PX0

IP.7: reserved

IP.6: reserved

IP.5: Timer 2 interrupt priority bit (8052 only)

IP.4: Serial port interrupt priority bit

IP.3: Timer 1 interrupt priority bit

IP.2: External interrupt 1 priority bit

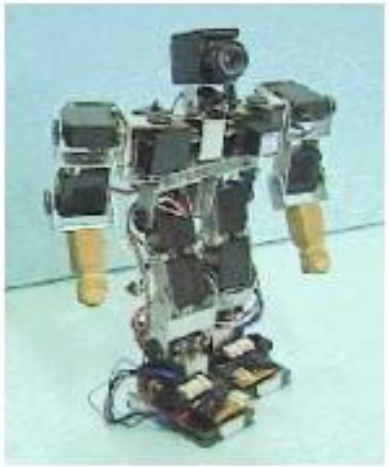
IP.1: Timer 0 interrupt priority bit

IP.0: External interrupt 0 priority bit

Applications of microcontrollers

- Cell phone
- Pager
- Watch
- Calculator
- video games
- Alarm clock
- Air conditioner
- TV remote
- Microwave oven
- Washing machines
- An electronic smart weight display system
- Robotic system
- An anti-lock braking system monitor

Examples of Research Robots that use Microcontrollers



Applications cont'd

- Hand Speak
- Enhance communication abilities of deaf people
- M16/62 Microcontroller converts American Sign Language (ASL) movements into alphanumeric characters that are displayed on LCD

Microprocessor vs Microcontroller

Microprocessor

- CPU is stand-alone, RAM,
  ROM, I/O, timer are
  separate
- designer can decide on the
  amount of ROM, RAM and
  I/O ports.
- Expansive
- versatility
- general-purpose

Microcontroller

- CPU, RAM, ROM, I/O and
  timer are all on a single
  chip
- fix amount of on-chip
  ROM, RAM, I/O ports
- Highly bit addressable
- for applications in which cost, power and space are critical
- single-purpose

History of 8051 microcontroller

- In the year 1980 Intel corporation introduced an 8 bit microcontroller called 8051.
- It has 4K bytes of ROM,128 Bytes of RAM , a serial port, two 16-bit Timers and 32 I/O pins.
- CPU can work with 8 bit of data at a time.
- Data larger than 8 bit can be broken into 8 bit pieces to be processed by the CPU

Interrupt inside an interrupt

---	---	PT2	PS	PT1	PX1	PT0	PX0

- A high-priority interrupt can interrupt a low-priority interrupt
- All interrupt are latched internally
- Low-priority interrupt wait until 8051 has finished servicing

  the high-priority interrupt

Applications of 8051 microcontroller

- Embedded system
- Industrial
- Computer networking
- Power input to the 8051 is very simple and straight forward.
- 8051 could be used in low-power applications.

Applications cont'd

- The 8051 has been in use in a wide number of devices, mainly because it is easy to integrate into a project or build a device around.

- **Energy Management:**
  - Efficient metering systems help in controlling energy usage in homes and industrial applications.
  - These metering systems are made capable by incorporating microcontrollers.

Applications cont'd

Touch screens:

- A high number of microcontroller providers incorporate touch-sensing capabilities in their designs.
- Portable electronics such as cell phones, media players and gaming devices are examples of microcontroller-based touch screens.

Automobiles:

- The 8051 finds wide acceptance in providing automobile solutions.
- They are widely used in hybrid vehicles to manage engine variants.
- Functions such as cruise control and anti-brake system have been made more efficient with the use of

Applications cont'd

Medical Devices:

- Portable medical devices such as blood pressure and glucose

  monitors use microcontrollers will to display data, thus

  providing higher reliability in providing medical results.