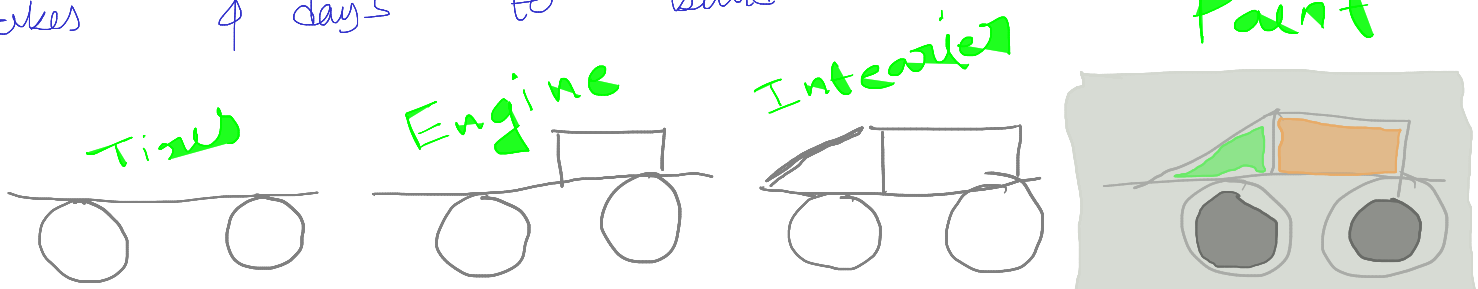
Packet switching in detail :

Pipelining : It is invented by Henry Ford the founder of Ford cars.

Before Industry revolution people drove horses, but the maintanance of horses was not cheap. Then the cars are invented but that cars also are not cheap and they are unreliable and manufacturing one car takes almost 6 months

After industry revolution, Henry Ford gathered all the experts to build cars and then one car takes 4 days to build



1 Day 2 Day 3 day 4 th day

So, Normally one car takes 4 day but we are not making only one car right b/c after revolution the cars were reliable & it costs less and maintenance were low So people wanted to buy cars so many cars were needed

Let's say he got order of 100 cars

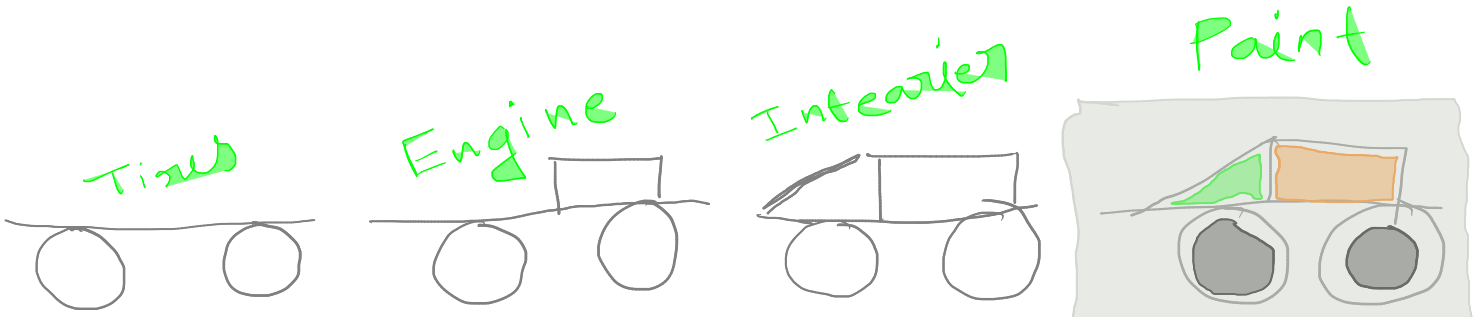
1 car takes 4 days

200 " " 4 × 100

= 400 "

It's too much time for making a customer wait.

So, he used a technique called pipelining



1 Day 2 Day 3 day 4 th day

1st day	1st car	—	—	—
2nd day	2nd car	1st car	—	—
3rd day	3rd car	2nd car	1st car	—
4th day	4th car	3rd car	2nd car	1st car

Even though the 1st car takes 4 day → the mechanics is not wasting time and they are working very efficiently. → So they next cars takes only 1 day.

1st car takes 4 day

rest 99 car takes 1 day

$(1 \times 4) + (99 \times 1) = 4 + 99$

$= 103$ days

So, we needed 400 days to make 100 cars but with pipelining we make them in just 103 days.

In Packet switching, we also use pipelining to speed up data transfer by dividing the packets in multiple parts and sending it with packet switching and pipeline ⟶ this is then called **Packetization**

Packetization:

Let's assume the size of the data = 1000 Bytes

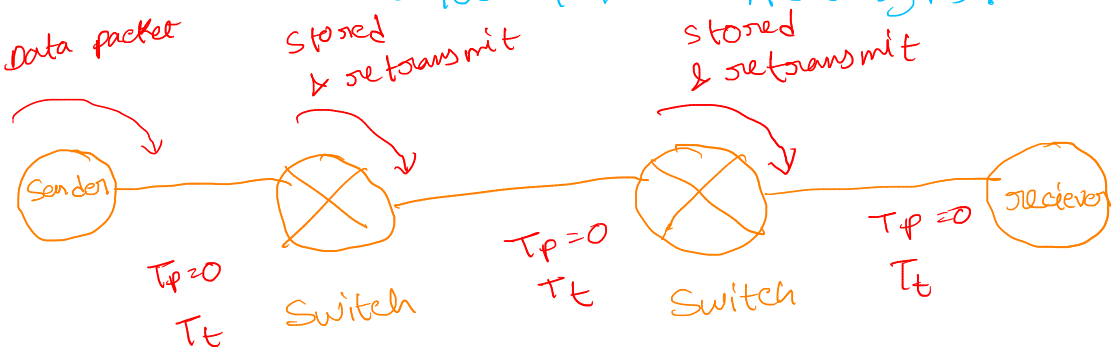
Bandwidth = 1 MBPS

= 10^6 B/S

Header = 100 Byte → b/c in packet switching the data is stored in every hop and the header decides which way to go.

So, total data size = Data + Header

= 1000 + 100 = 1100 Bytes.



Let's assume, for the sake of simplicity here propagation delay is 0 So, $T_p = 0$ & $T_t = \frac{\text{length of data}}{\text{Bandwidth}} = \frac{1100}{10^6}$

= 1.1 milisec.

In packet switching the data is stored in every hop & then it is re-transmitted according to header of the data.

So, Total time for data to travel from Sender to reciever

= 3 * T_t

= 3 * 1.1 milisec

= 3.3 milisec.

Sending data in packet-switching with packetization:

In packetisation pipeline is used and in pipeline multiple packets are used. So we can just divide the data in multiple packets to utilize packetization and make the transmisson faster.

Data = 1000 Bytes, Bandwith = 1 MBPS
$= 10^6$ B/S

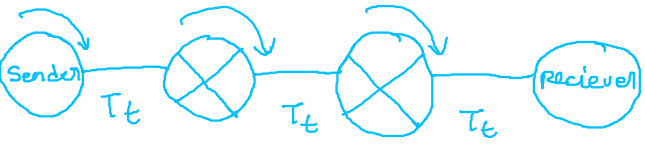
Packets = 5

each packet = $\frac{1000}{5}$ Bytes

= 200 Bytes

Packet + Header = 200 + 100

= 300 Byte



Let's assume $T_p = 0$

$T_t = \frac{L}{BW} = \frac{300}{10^6}$

= 0.3 milisec

Total time in Transmisson

$= 3 \times T_t = 3 \times 0.3$

= 0.9 milisec

if packets are = 10

then each packets = $\frac{1000}{10}$ Bytes

= 100 Bytes

Packet + header = 100 + 100

= 200

$T_t = \frac{200}{10^6}$ = 0.2 milisec

Total transmisson time

= 3 × 0.2

= 0.6 milisec

if we do same with 20 packets then

each packets = $\frac{1000}{20}$ Byte

= 50 Byte

Packet + Header = (50 + 100) Byte

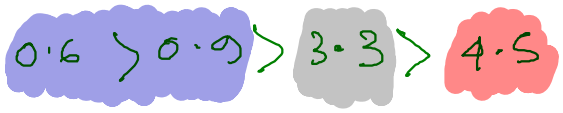
= 150 Byte

$T_t = \frac{150}{10^6}$

= 1.5 milisec

Total transmisson time

= 3 × 1.5 = 4.5 milisec



Here we can see packetization helped to transmit the data faster b/c when without packetization, we needed 3.3 milisec, Here with packetization we need lowest 0.6 milisec (10 packets) and 0.9 milisec (5 packets).

But we can't divide the data in too many packets b/c we have transmit header file with packets which is a overhead and b/c with packet, we are sending this overhead so if packet no. is many then this overhead may increase transmisson time.

So there should be a limit to which number we can divide the data in packets normally this number is 2^{16}