~The Parade~

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Raghu was very excited. He was in Delhi to participate in India's Republic day parade.

As you know, India's constitution came into force on January 26th, 1950. On this day, every year a grand parade is held in Delhi, which starts at the Rashtrapati Bhavan, winds through the city and ends at the Red Fort.

Different regiments of the Army, the Navy and the Air Force march past in all their finery and weapons. The parade is followed by a pageant of spectacular displays from the different states of the country. Raghu was one of the N.C.C cadets, selected from all over the country to participate in this event. So far, he had seen the parade only as telecast by the National Television and was now thrilled to be a part of it. They had spent many days preparing for the event and were now taking part in the final rehearsal.

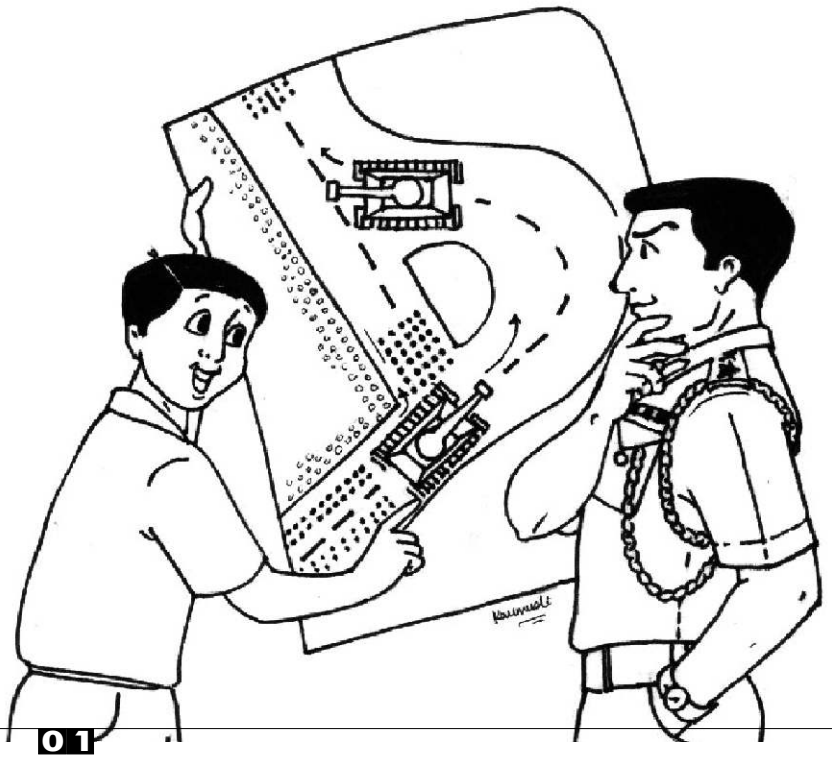
The rehearsal for the parade was being held on the Sunday previous to January 26th. The traffic department had made new traffic arrangements to ensure smooth movement on the roads. No traffic was permitted on the parade route from 6 am to 1 pm and cross traffic on the parade route was also closed from 8 am to 1 pm.

Raghu was thinking about how this route reservation for the parade was similar to what is done in telephone networks. "It is quite similar", he thought, "For each telephone call, a telephone network also has to reserve a line (circuit) between the telephones at the two ends. This circuit is like this parade route and all the communication goes through it only."

Suddenly the parade came to a halt. What was the problem?

There was a turning along the approach and one of the vehicles in the parade was too broad to take the turn smoothly. This was causing a delay and a break in the timing sequence of the parade. The officers in-charge had to decide between several possibilities:
(i) The road could be widened at that point to make the turning smooth.
(ii) The parade route could be changed to avoid this turning.
(iii) The vehicle could be excluded from the parade.
However, widening the road was difficult as there were some residential buildings close by. Changing the parade route would require a lot of re-routing of other traffic and upset other arrangements. Excluding the vehicle from the parade was not an option, as it was introduced specifically to carry one of the main items to be displayed during the parade. What was to be done?

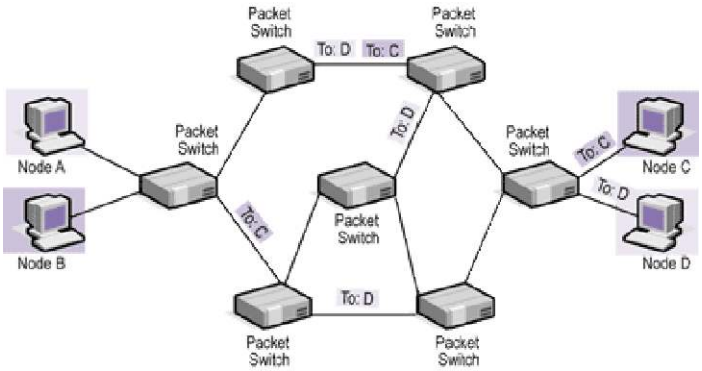
Meanwhile, Raghu had been considering the similarity between the parade and a telephone circuit. He went on to muse about the difference between telephone circuits and packet routing the Internet. Could some principle used in Internet routing also be applied to this parade? Raghu looked at the road stretch that was creating the problem. He looked around for an alternate road. Aha! He had an idea.



Fortunately, the officers in-charge were good to him and listened to his idea. They agreed that it would be the easiest one to implement and would cause the least disruption in the existing arrangements. It did not require widening of any roads, nor changing the route of the whole parade. The idea was very simple:

For the short stretch of road which was causing the problem, only the wide vehicle alone could take a different route. The vehicle would leave the parade just before coming to the problem stretch, move quickly along a parallel route and re-join the parade route after that stretch. While re-joining, it would merge back into its proper position in the parade.

So how is a parade similar to a telephone circuit and how is it related with the Internet?

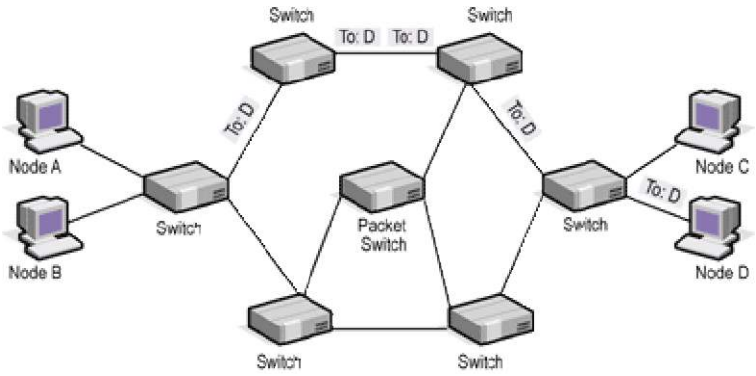


When you dial a telephone number, the telephone network reserves a specific physical path to the number you are calling. It links together wire segments (lines) to create a single unbroken path (circuit) for your call. For the duration of your call, no one else can use the physical lines involved in this path. This is similar to a set of roads being reserved for the parade. No other traffic may use these roads for the duration of the parade.

Such a type of communication in which a dedicated channel (or circuit) is established for the duration of a transmission is called circuit-switching. Circuit-switching is ideal when data must be transmitted without any delays and must arrive in the same order in which it is sent. However it may be wasteful because the circuits are idle during silent periods. For example, when one of the persons in a telephone call stops talking, the network lines along the dedicated path cannot be used by other ongoing connections. As a result, the capacity of the network to accommodate simultaneous calls is reduced.

Circuit-switching is also sensitive to failures of lines along the path. If any one of the lines in a path breaks down, the call gets disconnected and a new call has to be established all over again.
On the other hand, a message from one computer on the Internet to another gets divided into packets before being sent. Each packet is then transmitted individually and can even follow different routes to the destination. Once all the packets forming a message arrive at the destination, they are recompiled into the original message. This is similar to the wide vehicle leaving the parade, taking a different route and re-joining the parade subsequently.

Such a type of communication in which small units of data (or packets) are routed through a network, based on the destination address contained within each packet, is called packet-switching. Breaking the communication down into packets allows the same physical path to be shared among many users in the network.



As a result, the capacity of the network to accommodate simultaneous users is increased. Packet-switching is also more robust to failures along the path. If any link on the path breaks down, the packets can be re-routed to the destination, using other alternate paths. Packet switching is more efficient for data that can withstand some delays in transmission, such as e-mail and Web pages.

Here is another analogy to understand circuit-switching and packet-switching: consider two restaurants - one which requires advance reservations and another which neither requires reservations nor accepts them.

For the restaurant that requires reservations, we have to go through the hassle of first calling and reserving a table. But when we arrive at the restaurant, we can immediately get a table and order our meal. For the restaurant that does not require reservations, we don't need to bother to reserve a table. But when we arrive at the restaurant, all the tables may be occupied and we may have to wait in a queue for a table. The first restaurant is like a circuit-switch while the second one is like a packet-switch.

Interestingly, nowadays voice calls using the Internet's packet-switched system are also possible. Each end of the conversation is broken down into packets, transmitted over the Internet, and are reassembled at the other end.

While this may sound simple, a lot of intricacies have to be taken care of to ensure that the system works correctly. For example, How do we ensure that the packets arrive in the same order in which they are sent? What if there are variable delays between the packets? What if some packets are lost?

Circuit switching: A method of transmitting information (voice or data) through a system or network by establishing a persistent, dedicated connection ("circuit"). Most telephone networks work on this principle.

Packet switching: A method of transmitting information (voice or data) through a system or a network by dividing the messages into packets and sending each packet individually. The Internet works on this principle.

Some interesting related websites are:

http://www.webclasses.net/Courses/Protocols/7.0/DemoBuild/units/unit01/sec01a.html
http://www.techtutorials.info/netgen.html
http://www.howstuffworks.com/

Illustrations: Mrs. Kaumudi Sahasrabudhe