

Prepared by: Saba Neysabouri (CATSR, 2/12/130)

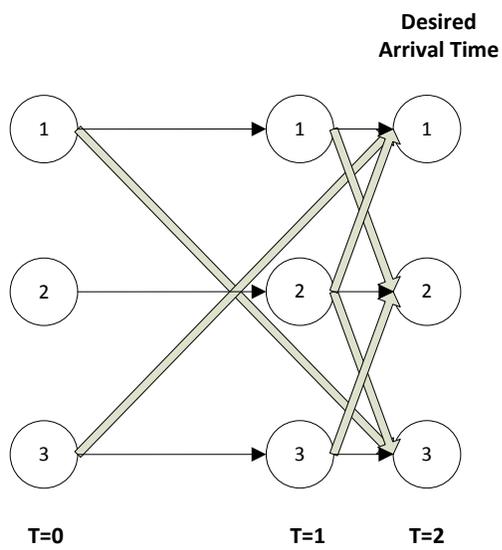
Transportation network structure:

Our network has 3 nodes and distance units are equal to time units.

Distance:

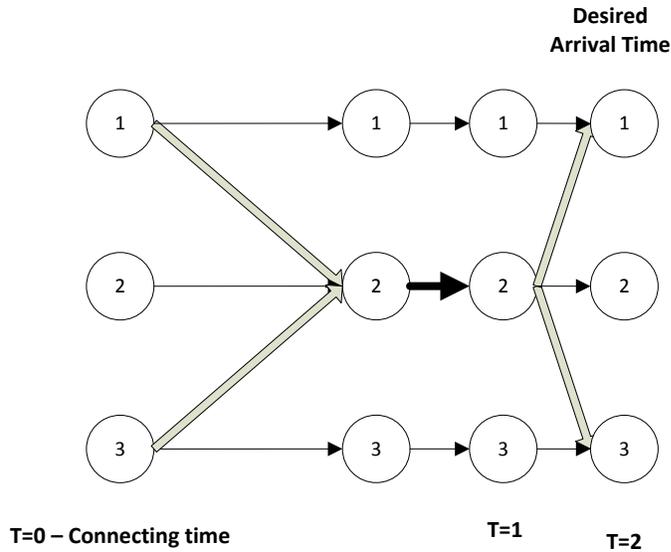
$D(1,2)=1$ ,  $D(1,3)=2$ ,  $D(2,3)=1$

Point-to-Point network:



Point-to-Point		
No.	Itineraries	Flights
1	1-2	F 1-2
2	1-3	F 1-3
3	2-1	F 2-1
4	2-3	F 2-3
5	3-1	F 3-1
6	3-2	F 3-2

Hub-n-Spoke network:



Hub-n-Spoke		
No.	Itineraries	Flights
1	I 1-2-3	F 1-2 * F 2-3
2	I 3-2-1	F 3-2 * F 2-1
3	I 1-2	F 1-2
4	I 3-2	F 3-2
5	I 2-1	F 2-1
6	I 2-3	F 2-3

Assuming each direct itinerary has 10 (k) passengers, then for the whole network (and 6 itineraries) we have 60 (6k) passengers.

Total number of passengers does not change for each network (However in reality this might not be true since the connecting itineraries offered by airlines might not be as attractive as the direct flights which might reduce the demand for travel, but here we do not consider marketing effects).

Total flights, as it can be seen in the drawings, reduces in Hub network. Number of itineraries in direct network is equal to the number of flights ( $n * (n-1)$ ) while the number of itineraries in a Hub network is  $(n-1)$ .

- Increased itineraries would cause extra resources required for airlines
- Passengers will enjoy direct itineraries thanks to zero connecting time

Total number of aircrafts required in direct network is equal to the flights (they will be simultaneous)  $(n*(n-1))$ . While hub network only needs  $(n-1)$  aircrafts since each aircraft can perform both incoming flights and outgoing flights with respect to the hub.

- Direct network will pose greater investment on airlines since they require greater number of aircrafts, hence pilots and staff, to operate the network.

Size of the aircrafts in direct network should be smaller since they only carry the passenger for each O/D pair. While in Hub network, each flight carries both passengers destined to go to hub and those who will flight to other destinations using connecting flights. In our example (having 10 pax for each direct itinerary) size of aircraft for direct itinerary is 10 while in hub network it is  $10*(n-1) = 20$ .

- Airlines would enjoy smaller number of aircrafts since they could take advantage of the economies of scale (less pilots, staff, managing many assets is not easy)

Total flight miles in direct network is greater than the hub network (due to increased number of operations). In our example in direct network the total is 8 while in hub network is only 4.

- Airlines benefit from hub network since they would spend less money on fuel

Total seat count is equal to the number of aircrafts multiplied by the size of each aircraft. In our example total seats in direct network is equal to 60 (pax) while in hub network is equal to 40.

Total ASM is equal to size\*Total Mile flown. In Direct network it is equal to 80 and in hub network is equal to 80.

Average flight distance (for each flight) in our example is reduced for hub network. The value in direct network is 1.33 while it is equal to 1 for hub network.

- ATC which is concerned with safety prefers smaller flight times since it will automatically decrease the risks inherent in flights.

Average trip time in direct network is equal to the average flight time (since each flight is exactly one trip). But in hub network the connecting time should be added to the trip time for those who use connecting flights. Assuming one unit of time for connections, the average trip time in our hub network becomes 2 time units (4 trips are equal to 1 while 2 of them have 3 units of time).

- Passengers would be the victim in this scenario since they have to plan for the increased travel time.

Maximum simultaneous arrivals and departures are reduced in hub network. As it can be seen from our network drawings, direct network has 6  $(n*(n-1))$  simultaneous operations while hub structure has only 2  $(n-1)$  simultaneous operations.

- ATC is the primary beneficiary of hub and spoke structure for this case. The reason is the number of flights to be managed (traffic) is reduced considerably which in turn will decrease the

controller workload and increase safety of operations. Airports would also benefit since they require less facilities (gates). Airlines would also benefit since they are the one who are building the facilities (terminals and gates) at the airports!

	Direct	Hub-n-Spoke
Total Pax	60	60
Total Itineraries	6	6
Total Flights	$3*2=6$	$2*2=4$
Total Aircrafts Required	6	2
Size	10	20
Total Flight Miles	8	4
Total Seats	60	40
Total ASM	$10*8=80$	$20*4=80$
Total Arrival Displacement time	0	connecting time
Average Flight Distance	1.33	1
Average trip Time	1.33	1.66(1 unit connecting)
Max Simultaneous Arr/Dep	6	2