Monitoring Network Performance using NetScan

The size and quality of airline networks may be assessed using distinct types of indicators. Most benchmark analyses between airports or airlines use relative simple, easy to communicate indicators, such as number of destinations and frequencies of direct connections to particular destinations. But also indirect connections contribute significantly to the accessibility by air between airports and regions. Moreover, the large hubs and their airlines focus particularly to indirect connections, as these are indispensable to retain particular market shares.

The size and quality of networks, including indirect connections, are less easy to communicate. The *NetScan* model is developed to monitor this by looking at "*connectivity*": a representation of the physical characteristics of connections: number of frequencies weighted by their *quality*. Quality is defined here as how fast the connection is and this quality is represented by an index. This *quality index* ranges from 1 (one) for direct connections with the shortest possible travel time, to 0 (zero) when travel time (of indirect connections) exceeds particular predefined limits. Multiplying the quality index with the weekly frequency results in the *number of connectivity units* between two airports.

Next table provides an overview of connectivity of all connections of the SkyTeam alliance from Copenhagen (CPH) to Bangkok (BKK), based on the schedule of September 2007. There are two alternatives that the SkyTeam alliance offers: via Amsterdam (AMS) and Paris (CDG). Furthermore, there are two options when travelling via Amsterdam. Firstly, leaving Copenhagen with KLM (KL) at 14:25 in the afternoon, arriving at Amsterdam at 15:55. As the KLM-flight to Bangkok leaves as late as 20:45, there is a connecting time of 4 hours and 50 minutes. Hence, this option has a low quality index of 0.012 only. This option is offered 7 times per week and multiplying this frequency with the quality index (0.012), results in the connectivity value of this connection, expressed in connectivity units (CNU) of 0.08.

A better performance has the other option, leaving Copenhagen three hours later at 17:25, connecting to the same flight to Bangkok from Amsterdam. The connecting time at Amsterdam is therefore three hours shorter and hence the quality index and connectivity values of this option is higher (0.54 and 3.75 respectively). Taking both options together, the total connectivity value between Copenhagen and Bangkok of SkyTeam via Amsterdam is 3.84 units.

Connectivity of the SkyTeam alliance between Copenhagen (CPH) and Bangkok (BKK), September 2007

Leg 1					Leg 2						
Route	Airline	Schedule	Flight time	Transfer Time	Route	Airline	Schedule	Flight time	Freq	Quality	CNU
CPH-AMS	KL	14:25-15:55	1:30	4:50	AMS-BKK	KL	20:45-12:30	10:45	7	0.01	0.08
CPH-AMS	KL	17:25-18:55	1:30	1:50	AMS-BKK	KL	20:45-12:30	10:45	7	0.54	3.75
CPH-CDG	AF	15:35-17:35	2:00	1:45	CDG-BKK	AF	19:20-11:45	11:25	7	0.46	3.21
								Total CPH-BKK via SkyTeam –AMS	14	0.27	3.84
								Total CPH-BKK via SkyTeam –CDG	7	0.46	3.21

Similarly, the connectivity value of the SkyTeam (Air France in this case) connections via Paris can be determined, resulting in 3.21 units, as the table shows.

The connectivity performance of all other travel options between Copenhagen and Bangkok can be determined by applying the same methodology, as the table below shows.

There are two airlines offering direct flights: Scandinavian Airlines and Thai International Airways, both members of the STAR-alliance, with 6 and 7 weekly frequencies respectively. These are direct and also non-stop flights. Hence, there is no time loss and therefore the quality index of these connections equals 1. There is furthermore a variety of indirect connections, most of them also offered by airlines belonging to the STAR-alliance.

Direct and Indirect Connectivity between Copenhagen (CPH) and Bangkok (BKK)

Route:	Circuitry (%)	Airline(s)	Frequency	Quality Index	Connectivity (CNU)
STAR Alliance					
Direct					
	-	SK	6	1.00	6.00
	-	TG	7	1.00	7.00
Indirect from CPH to BKK via:					
ARN Stockholm	2	SK-TG	24	0.37	8.95
MUC Munich	11	LH-TG	7	0.42	2.96
		SK-TG	6	0.58	3.49
FRA Frankfurt	12	LH-LH	7	0.60	4.19
		LH-TG	7	0.29	2.05
		SK-LH	7	0.29	2.05
		SK-TG	23	0.26	6.04
ZRH Zurich	16	SK-TG	7	0.21	1.44
		SK-LX	5	0.25	1.24
ATH Athens	17	SK-TG	3	0.33	0.99
MXP Milan Malpensa	18	SK-TG	3	0.13	0.40
CDG Paris	21	SK-TG	7	0.17	1.21
FCO Rome	21	SK-TG	4	0.37	1.47
LHR London	22	SK-TG	14	0.30	4.15
MAD Madrid	42	SK-TG	3	0.41	1.24
NRT Tokyo	55	SK-NH	7	0.23	1.62
		SK-TG	7	0.21	1.46
SkyTeam Alliance					
Indirect via:					
AMS Amsterdam	14	KL-KL	14	0.27	3.84
CDG Paris	21	AF-AF	7	0.46	3.21
oneWorld					
Indirect via:					
HEL Helsinki	2	AY-AY	7	0.06	0.42
BUD Budapest	7	MA-MA	2	0.62	1.23
LHR London	22	BA-BA	12	0.42	4.98
		BA-QF	12	0.37	4.38
Independent airlines					
Indirect via:					
IST Istanbul	10	TK-TK	2	0.44	0.88
SUMMARY by Alliance					
Sky Team			21	0.34	7.05
STAR Alliance			187	0.38	71.22
One World			33	0.33	11.02
Independent			2	0.44	0.88
TOTAL Copenhagen – Bangkok					
Direct Connectivity			**13**	**1.00**	**13.00**
Indirect Connectivity			**230**	**0.34**	**77.17**

Most of the indirect STAR Alliance connections connect at the typical STAR-hubs, such as the ones of Lufthansa (Frankfurt, Munich), the secondary Scandinavian hub (Stockholm) and the one of Swiss (Zurich). Most connections lead via Frankfurt, where the SK and LH-flights from Copenhagen to Frankfurt connect with the LH- and TG-flights out of Frankfurt to Bangkok. As these are indirect connections, there is time loss in comparison with direct connections and hence their quality index is less than 1. The time loss is caused by two reasons. Firstly it is caused by the longer flight distance in comparison to the great circle distance between Copenhagen and Bangkok. The route via Frankfurt is 12% longer than the great circle distance: the circuitry is 12%. Secondly time loss is caused by the longer elapsed travel time (flight time plus connecting time). While all connections via Frankfurt have by definition the same circuitry percentage, their quality index is not necessarily the same. The latter difference is determined by differences in connecting time. Looking at the quality indices of the connections via Frankfurt, the LH-LH connections have the best performance, which is an indication that the Lufthansa arrivals from Copenhagen into Frankfurt are on average well connected to the Lufthansa departures out of Frankfurt to Bangkok. The coordination between the other airlines at Frankfurt (SK-LH, SK-TG and LH-TG) is on average less optimal.

Of all the typical STAR-hubs, the shortest route is via Stockholm, with a circuitry factor of 2% only. Although this short circuitry contributes to a higher quality index, the quality index of connections via Stockholm (0.37) is still far below the index value of the LH-LH-connections via Frankfurt (0.60), indicating that there is still a potential for optimizing the coordination at Stockholm. The routes via the two other STAR-hubs Munich and Zurich are slightly longer than the routes via Frankfurt.

With the STAR-alliance also connections can be made at other hub airports than the typical STAR-hubs, such as Paris, London and Madrid. Most of these connections are made by the Scandinavian flights into these hubs, connecting to the Thai flights out of these hubs. The circuitry percentages of these routes are higher than the routes via the STAR-hubs, ranging from 17% in case of a connection via Athens to 44% in case of a connection via Madrid and even 55% in case of a connection via Tokyo. Despite the length of the route via Madrid, its quality index is still 0.41, even higher than the quality index of the route via Stockholm with the shortest circuitry. This is a indication that Scandinavian arrivals into Madrid are well connected to the Thai-departures out of Madrid and the longer distance is compensated by the short connecting time.

Apart from the STAR-alliance, indirect connections are also offered by other alliances, although their share in total connectivity is relatively low. The ones of SkyTeam are discussed above. The oneWorld alliance offers connections via London, Budapest and Helsinki. The low quality index of connections via Helsinki is worth addressing. Despite of the very short circuitry (2% only, similar to Stockholm), the quality index is still 0.06 only, an indication of the poor coordination of arrivals to departures at Helsinki in the Copenhagen-Bangkok market.

Airport Connectivity: Four Perspectives

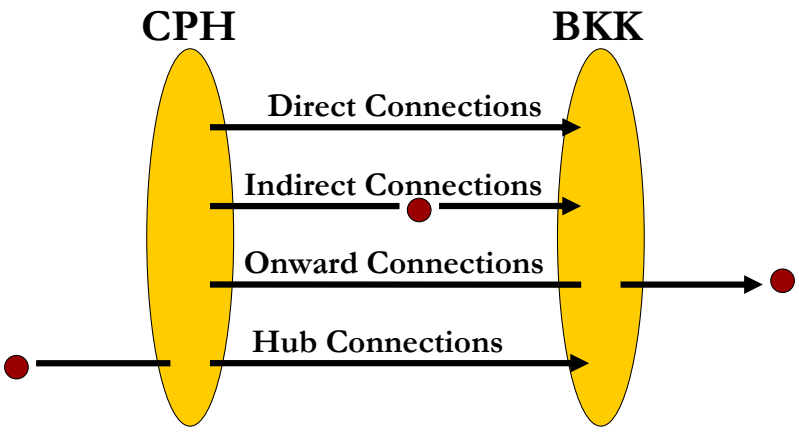
Airports can look to connections from four types of perspectives. Two of them have been addressed above. For the route Copenhagen – Bangkok these perspectives are:

- Direct Connectivity: Direct connections, without an intermediate hub connection point: CPH -BKK
- Indirect Connectivity: Indirect connections from Copenhagen to Bangkok via any intermediate hub H: CPH - H - BKK

The two other relevant perspectives are:

- Onward Connectivity: Indirect connections from Copenhagen via Bangkok to any point Y beyond Bangkok: CPH - BKK - Y
- Hub Connectivity: Indirect connections from any point X behind Copenhagen via Copenhagen to Bangkok: X - CPH - BKK

These first two perspectives, direct and indirect connectivity have been discussed above. One may however not only look to indirect connections from Copenhagen via any hub to Bangkok, but also to indirect connections from Copenhagen via Bangkok to any destination beyond Bangkok. The latter indirect connections are indicated as **onward connections** from Copenhagen to (points beyond) Bangkok. Hence, onward connectivity refers to indirect connections from Copenhagen via Bangkok to points (Y) beyond Bangkok. It is conceived that such points are located in South East Asia as well as in Australia /New Zealand. Next table lists these onward connections.



From the table on the next page, it is firstly seen that all onward connections from Copenhagen to destinations beyond Bangkok are provided by the STAR-Alliance. The vast majority are TG-TG or SK-TG connections. All other airline combinations refer to airlines belonging to the STAR-alliance. Another remarkable observation is that the circuitry factor of the route via Bangkok to some of the points beyond Bangkok is extremely low, such as to Singapore, Jakarta and Sydney. This indicates that the hub Bangkok is (in geographical respect) ideally located, practically on the straight line to be drawn between Copenhagen and these points. To other points this circuitry factor is higher and the most extreme example is the route from Copenhagen via Bangkok to Tokyo, which has a circuitry of 52%, which can be understood looking to the geographical location of these points.

Onward Connectivity from Copenhagen (CPH) to destinations beyond Bangkok (BKK)

Route:	Circuitry (%)	Airline(s)	Frequency	Quality Index	Connectivity (CNU)
STAR Alliance					
Indirect from CPH via BKK to:					
Domestic (Thailand)					
CNX Chiang Mai	14	SK-TG	12	0.20	2.39
		TG-TG	14	0,29	3.99
HKT Phuket	3	SK-TG	12	0.48	5.77
		TG-TG	14	0.66	9.25
KBV Krabi	3	SK-TG	6	0.19	1.13
		TG-TG	7	0.59	4.16
International					
KUL Kuala Lumpur	2	SK-TG	12	0.38	4.60
		TG-TG	7	0.44	3.09
HAN Hanoi	16	SK-TG	6	0.23	1.39
		TG-TG	7	0.39	2.74
SGN Ho Chi Minh City	1	SK-TG	8	0.42	3.35
		TG-TG	7	0.44	3.09
SIN Singapore	1	SK-LX	6	0.77	4.61
		SK-SQ	12	0.43	5.16
		SK-TG	12	0.39	4.67
		TG-SQ	14	0.38	5.25
		TG-TG	14	0.36	5.05
CGK Jakarta	1	TG-TG	7	0.63	4.43
SYD Sydney	1	SK-TG	4	0.40	1.60
		TG-TG	7	0.66	4.62
HKG Hong Kong	19	SK-TG	18	0.38	6.85
		TG-TG	7	0.44	3.07
TPE Taipei	26	SK-TG	12	0.26	3.12
		TG-TG	7	0.53	3.73
NRT Tokyo	52	TG-TG	7	0.14	0.99
		TG-NH	7	0.25	1.75
		TG-UA	7	0.38	2.66
Other points beyond BKK			85	0.37	31.19
SUMMARY by Airline Combination					
		SK-LX	6	0.77	4.61
		SK-SQ	12	0.43	5.16
		SK-TG	126	0.31	38.58
		TG-NH	7	0.14	0.99
		TG-SQ	14	0.38	5.25
		TG-TG	166	0.46	76.46
		TG-UA	7	0.38	2.66
TOTAL Copenhagen – Bangkok Onward Connectivity			**338**	**0.40**	**133.71**

The average quality index of all these connections is 0.40, however with some examples of significantly higher quality indices. Notably good is the SK-LX connection via Bangkok to Singapore (0.77), as well as the TG-TG connections to Phuket (0.66), Jakarta (0.63) and Sydney (0.66). The TG-TG connections via Bangkok to Singapore seem to have some potential for optimizing coordination between arrivals and departures, looking to the low circuitry factor, but also the low average quality index (0.36) of these connections.

The final category of relevant indirect connections refers to indirect connections from any origin via Copenhagen to Bangkok. These connections are indicated as **hub connections** from any point via Copenhagen to Bangkok. Hence, hub connectivity refers to indirect connections from any origin (X) via Copenhagen to Bangkok. It is conceived that such origin points are located in Europe, being the ideal area from which connections feed into Copenhagen with final destination Bangkok. Next table lists these hub connections.

Hub Connectivity from origins behind Copenhagen (CPH) to Bangkok (BKK)

Route:	Circuitry (%)	Airline(s)	Frequency	Quality Index	Connectivity (CNU)
STAR Alliance					
Indirect via CPH to BKK from:					
ARN Stockholm	11	SK-SK	21	0.42	8.82
		SK-TG	17	0.30	5.17
OSL Oslo	5	SK-SK	22	0.38	8.39
		SK-TG	25	0.36	8.91
HEL Helsinki	20	KF-SK	7	0.43	2.96
		KF-TG	7	0.39	2.71
		SK-SK	8	0.13	1.03
		SK-TG	5	0.60	2.98
LHR London	0	SK-SK	12	0.50	5.99
		SK-TG	12	0.45	5.34
AMS Amsterdam	1	SK-SK	17	0.28	4.83
		SK-TG	7	0.47	3.31
FRA Frankfurt	4	SK-SK	12	0.45	5.37
		SK-TG	7	0.32	2.24
		LH-SK	6	0.08	0.49
		LH-TG	7	0.04	0.28
MUC Munich	7	SK-SK	11	0.34	3.79
		SK-TG	7	0.21	1.45
BRU Brussels	1	SK-SK	11	0.47	5.15
		SK-TG	11	0.55	6.00
ZRH Zurich	6	SK-SK	11	0.39	4.27
		SK-TG	7	0.53	3.74
		LX-SK	6	0.26	1.58
MAD Madrid	5	JK-SK	3	0.26	0.79
		JK-TG	5	0.59	2.96
FCO Rome	15	SK-SK	2	0.62	1.23
SEA Seattle	37	SK-TG	7	0.38	2.65
Other points behind CPH			418	0.47	196.08
SUMMARY by Airline Combination					
		SK-SK	268	0.42	111.69
		BD-SK	9	0.29	2.64
		JK-SK	9	0.45	4.06
		JP-SK	2	0.43	0.86
		KF-SK	7	0.42	2.96
		LH-SK	6	0.08	0.49
		LO-SK	6	0.22	1.29
		LX-SK	6	0.26	1.58
		OS-SK	12	0.38	4.51
		SK-TG	310	0.47	144.22
		BD-TG	12	0.42	5.03
		JK-TG	23	0.47	10.71
		KF-TG	7	0.39	2.71
		LH-TG	7	0.04	0.28
		TP-TG	7	0.79	5.50
TOTAL Copenhagen – Bangkok Hub Connectivity			**691**	**0.43**	**298.52**

As with the onward connections beyond Bangkok, there are also with these hub connections behind Copenhagen some examples with an extreme low circuitry factor. Notable examples are the connections from London and Amsterdam to Bangkok, for which the hub Copenhagen is located almost on the straight line to be drawn between these points and Bangkok. For other origin point, the hubs Copenhagen is less ideal, such as Helsinki, higher up in Scandinavia, for which the route via Copenhagen is a significant detour.

Most of the hub connections are provided by the SK-SK and SK-TG combinations. Moreover, there are several other European STAR-alliance partners, which flights into Copenhagen connect to the SK- and TG-flights out of Copenhagen. Examples of such combinations are LH-SK and LH-TG, providing connections from the German airports via Copenhagen to Bangkok. Other examples are the combinations JK-SK[1] and JK-TG, providing connections from the Spanish airports via Copenhagen to Bangkok.

In- and Outbound Connectivity

All examples provided above have shown outbound connections (from Copenhagen to Bangkok). However, the connectivity performance of inbound connections is not necessarily the same, particularly if indirect connections are considered.

Generally, the quality index of direct connections equals 1. Furthermore, if the outbound direct frequency equals inbound direct frequency (which is generally the case, unless triangle return trips are made), the direct outbound connectivity equals the direct inbound connectivity.

Generally, this is not the case for indirect connections. Although the elapsed flight time may still be the same for the outbound and the inbound (return) flight, the connecting time may be significantly different and so the quality index as well as the total number of connectivity units may be different. Next table illustrates this for the Copenhagen-Bangkok route.

Inbound and Outbound Connectivity indicators between Copenhagen (CPH) and Bangkok (BKK)

	Outbound CNU CPH - BKK	Inbound CNU BKK - CPH	**Average CNU**
Direct Connectivity	13.00	13.00	**13.00**
Indirect Connectivity	77.17	63.51	**70.34**
Onward Connectivity	133.71	100.76	**117.24**
Hub Connectivity	298.52	335.50	**317.01**

The table shows that direct outbound and direct inbound connectivity is indeed the same. However, connectivity on the indirect flights differs. Looking to – for instance - the indirect connections from Copenhagen to Bangkok, the outbound connections perform slightly better, which may be related to the (on average) shorter connecting time on the outbound connections.

In our connectivity approach, we take only the average between the two directionalities (out- and inbound), which has been illustrated in the table.

[1] JK is Spanair, the Spanish STAR-alliance partner

Connectivity Ratios

In the above the four types of connectivity have been addressed separately. However, one may reach relevant conclusions in relating the various types with each other.

There are two airlines operating direct flights from Copenhagen to Bangkok: Scandinavian (SK) and Thai International (TG). Both airlines give access to the network beyond Bangkok, predominantly provided by TG. There are 13 direct connectivity units, giving access to 117.24 onward connectivity units beyond Bangkok. Therefore (on average) every single direct connectivity unit gives access to 9.0 onward connectivity units beyond Bangkok. One may now define the **onward connectivity ratio** (OCR): the ratio between the total onward connectivity and direct connectivity units (117.24 / 13.00 = 9.0).

Furthermore, one may make a distinction between the OCR's of SK and TG. The OCR-ratio of TG is slightly better than the similar ratio of SK (9.3 and 8.7 respectively). This is an indication that the TG-flight to Bangkok is slightly better connected to the onward (mainly TG-) network beyond Bangkok than the SK-flight. Next table summarizes these ratios.

Connectivity Ratios between Copenhagen (CPH) and Bangkok (BKK)

CPH Copenhagen		Onward Connectivity		Direct Conn'ty	Hub Connectivity	
		CNU	Ratio	CNU	CNU	Ratio
BKK Bangkok	SK	51.99	8.7	6.00	134.53	22.4
BKK Bangkok	TG	65.24	9.3	7.00	182.48	26.1
BKK Bangkok	**Total**	**117.24**	**9.0**	**13.00**	**317.01**	**24.4**

In addition, we can define similar ratios for hub connectivity. The direct flights to Bangkok are fed (from mainly European origins) by 317.01 hub connectivity units behind Copenhagen. Therefore (on average) every single direct connectivity unit is fed by 24.4 hub connectivity units behind Copenhagen. One may now define the **hub connectivity ratio** (HCR): the ratio between the total hub connectivity and direct connectivity units (317.01 / 13.00 = 24.4). There is again a slight difference between the HCR's of SK and TG. The ratio of TG is slightly better than the similar ratio of SK (26.1 and 22.4) respectively, being an indication the TG-flight to Bangkok is slightly better connected to the feeder (mainly SK-) network behind Copenhagen than the SK-flight.

Finally, the difference between the onward (OCR) and hub connectivity ratio (HCR) is striking. The HCR is significantly higher than the OCR, being an indication that the European feeder network to the direct CPH-BKK flights is much denser (on average 24 feeder connections) than the onward network beyond Bangkok into Asia/Pacific (on average 9 onward connections).

The above example has shown an example of a route where both airlines have access to onward networks beyond the destination as well as are fed by the hub network behind the origin. This is because both airlines have a code share agreement and are even belonging to the same (STAR-) alliance. However, this is generally not the case, which is shown by the example below. This example refers to the route from Copenhagen to Newark (EWR). There are two airlines having direct flights between the two airports: Scandinavian (SK) and Continental (CO). Newark is Continental's hubs, and the direct flight of CO from Copenhagen to Newark has access to the onward network beyond Newark into (mainly) the USA. The resulting OCR-ratio is 29.0, being an indication of

the dense CO-network into the USA. The SK-flight to Newark has no access to the domestic CO-network into the USA, as the two airlines are competing and have no code share agreements. There is limited access of the SK-flight to some STAR-partner flights, such as the United-flight to Chicago etc. The SK-flight has a therefore a limited OCR-ratio of 3.1.

On the European side, it is SK only, who feeds the direct flights to Newark, with a HCR-ratio of 17.5. This is slightly worse than the feeder network into Bangkok (HCR=22.4). This is understood by looking to the location of the European hinterland vis-à-vis the flights to Bangkok and Newark respectively. In summary, total OCR and HCR of the CPH-EWR connection is 16.1 and 9.1 respectively.

Connectivity Ratios between Copenhagen (CPH) and Newark (EWR)

CPH Copenhagen		Onward Connectivity		Direct Conn'ty	Hub Connectivity	
		CNU	Ratio	CNU	CNU	Ratio
EWR Newark	SK	22.03	3.1	7.00	122.57	17.5
EWR Newark	CO	202.96	29.0	7.00	5.01	0.7
EWR Newark	**Total**	**224.99**	**16.1**	**14.00**	**127.58**	**9.1**

The Connectivity Matrix

All relevant connectivity indicators of Copenhagen can be brought together in the **connectivity matrix of Copenhagen**, listed below. The upper row represents direct connectivity. Direct connectivity (DC) to BKK is specified, but DC's to the other destinations are also specified in the upper row. In total Copenhagen has 2520 weekly connectivity units (September 2007), of which the majority of DC's to European destinations (2168).

The row below the direct connectivity represents the indirect connectivity (IC). IC to Bangkok is 70, as shown also above, but IC's to the other destinations are also specified, 3497 indirect connectivity units in total. It is observed that the majority of IC's has a final destination outside Europe. Indirect connectivity to European destinations is limited. The distance from Copenhagen to these final European destinations is short (generally below two hours) and the total elapsed time of an indirect connection via another European hub is too long, to result in non-zero quality indices and connectivity.

Furthermore, the indirect connectivity row is broken down into location of intermediate hub. Indirect connectivity to Bangkok for instance (70 CNU's) connects mainly at European airports, such as Frankfurt (15), London (11), Amsterdam and Paris (both 4 CNU's) and other European airports, such as Stockholm, Helsinki, Zurich and Vienna (34 CNU's).

The rows below the total indirect connectivity row represent therefore the breakdown into hub locations of indirect connections. Therefore the row totals represent the total onward connectivity via these hubs (or hub locations). Returning to the example of Bangkok, this hub has in total 117 CNU's from Copenhagen, of which 19 with final destination in North East Asia (China, Korea and Japan), 21 with final destination in Singapore, 65 in the rest of South East Asia and finally 13 in Oceania (Australia and New Zealand).

Connectivity Matrix of Copenhagen (CPH)

	TOTAL	LHR London	AMS Amsterdam	CDG Paris	FRA Frankfurt	Rest Europe	EWR Newark	ATL Atlanta	ORD Chicago	IAD Washington	Rest North America	Latin America	Africa	Middle East	North East Asia	BKK Bangkok	SIN Singapore	Rest South East Asia	Oceania	OCR
Direct Conn'ty to →	**2520**	**80**	**82**	**65**	**48**	**2168**	**14**	**5**	**7**	**7**	**10**			**3**	**14**	**13**	**3**	**1**		
Indirect Conn'ty to →	**3497**	**0**		**1**	**0**	**413**	**52**	**34**	**99**	**62**	**1711**	**202**	**199**	**90**	**272**	**70**	**94**	**172**	**26**	**1.4**
via LHR London	**419**					11	5		30	10	176	21	47	8	47	11	28	16	9	**5.2**
via AMS Amsterdam	**233**	0		0		8	7	6	6	4	91	35	22	7	21	4	7	15		**2.8**
via CDG Paris	**301**					26	9	7	5	10	48	48	60	8	32	4	5	8		**4.6**
via FRA Frankfurt	**420**			1		41	10	3	14	20	23	23	32	23	50	15	21	33		**8.8**
via Rest Europe	**785**	0		0	0	327	14	1	27	15	47	47	38	42	73	34	11	25		**0.4**
via EWR Newark	**225**							9	10	5	191	10								**16.1**
via ATL Atlanta	**336**						2		3	0	318	13								**67.2**
via ORD Chicago	**304**						1	4		0	297	2								**43.4**
via IAD Washington	**275**						3	4	4		260	3								**39.3**
via Rest North America	**30**								1		29									**3.0**
via Latin America																				
via Africa																				
via Middle East	**1**												0	1						**0.3**
via North East Asia	**32**														28	2	2			**2.3**
via BKK Bangkok	**117**														19		21	65	13	**9.0**
via SIN Singapore	**16**														2	1		9	4	**5.3**
via Rest S. East Asia	**2**																	2		**2.0**
via Oceania																				

	TOTAL	LHR London	AMS Amsterdam	CDG Paris	FRA Franffurt	Rest Europe	EWR Newark	ATL Atlanta	ORD Chicago	IAD Washington	Rest North America	Latin America	Africa	Middle East	North East Asia	BKK Bangkok	SIN Singapore	Rest South East Asia	Oceania	HCR
Hub Conn'ty to →	**3282**	**42**	**35**	**44**	**58**	**1890**	**128**	**8**	**130**	**129**	**151**				**285**	**317**	**63**			**1.3**
from LHR London	**42**					11	2		3	2	4				9	10	2			**0.5**
from AMS Amsterdam	**35**					8	3	1	2	2	2				7	8	1			**0.4**
from CDG Paris	**44**					15	2	2	2	2	4				8	8	1			**0.7**
from FRA Frankfurt	**58**					12	5		6	5	7				12	9	3			**1.2**
from Rest Europe	**1890**	11	8	15	12	775	115	5	115	117	133				249	278	56			**0.9**
from EWR Newark	**128**	2	3	2	5	115										0	1			**9.1**
from ATL Atlanta	**8**		1	2		5														**1.6**
from ORD Chicago	**130**	3	2	2	6	115									0	2				**18.6**
from IAD Washington	**129**	2	2	2	5	117										0	1			**18.4**
from Rest North America	**151**	4	2	4	7	133										1				**15.1**
from Latin America																				
from Africa																				
from Middle East																				
from North East Asia	**285**	9	7	8	12	249			0											**20.4**
from BKK Bangkok	**317**	10	8	8	9	278	0		2	0	1									**24.4**
from SIN Singapore	**63**	2	1	1	3	56	1			1										**21.0**
from Rest S. East Asia																				
from Oceania																				

The matrix shows that indirect connections and onward connections from Copenhagen are in fact the same connections. The total indirect connectivity row gives a breakdown of these connections into final destination, while the total onward connectivity column gives a breakdown of these connections into intermediate hub.

Note finally the onward connectivity ratio's (OCR) in the right part of the matrix. The OCR ratio of flights from Copenhagen to Bangkok (9.0) has been discussed above. The OCR-ratio's of flights top some hubs in the USA is significantly higher, such as the ones to Atlanta, Chicago and Washington. Only Delta has flights from Copenhagen to Atlanta, where it finds access to a dense network further onward into the USA (OCR=67.2). Only Scandinavian has flights to Chicago and Washington, both hubs of United Airlines, the STAR-alliance partner of SK. Therefore SK has access to the dense onward networks of UA with OCR-ratios of 43.4 and 39.3 respectively.
While the middle part of the above matrix can be indicated as the 'indirect connectivity matrix', the lower part is the hub connectivity matrix. Returning to the example of Bangkok, total hub connectivity via Copenhagen is 317 CNU's. The matrix gives furthermore a breakdown of these CNU's into origin, mainly in Europe, and to a very limited extent North American origins are involved.

Again, the intra European hub connectivity is relatively limited. Most of the hub connections via Copenhagen refer to connections between European and non-European airports (or vice versa). Finally hub connections between non-European airports are almost negligible.

Note finally, the hub connectivity ratios, of which the one to Bangkok (24.4) has been discussed above. The HCR-ratios to other Asian destinations have values of the same order of magnitude. The HCR-values to North America are somewhat lower, which phenomenon is related to the location of the European hinterland vis-à-vis these North American destinations.