Analyzing the Impacts of Market Input Parameters on the Total Required Spectrum for IMT-Advanced for Future Needs

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ABSTRACT
The ITU spectrum calculation methodology uses a limited set of market study parameters to characterize the future wireless services. The market study parameters characterize the demand of twenty different Service Categories (SC 1-20) in six Service Environments (SE 1-6) in three forecast years. There are regional differences in the market development, i.e. in some parts of the world a particular level of market development may be reached earlier or later than in the (average) "global common market". To characterize the difference in the market development and RAT Group deployment scenarios in different countries, the time shift approach is used to calculate the spectrum requirements. This paper presents the impacts of Market input parameters on the total required spectrum for IMT-Advanced by 2015 and 2020.

Keywords
ITU, IMT-Advanced, TRAI, RATG, WRC.

1. INTRODUCTION
IMT-Advanced standard is given to the future mobile wireless technologies. It is still in the finalizing phase. At this time, in every country the required spectrum is being calculated by their respective Authority. In India, TRAI is also working on this issue. In WRC-07 (World Radio Conference – 2007), the required spectrum for IMT-Advanced has been calculated using the tool 'SPECULATOR', which is implemented in MS-Excel. The ITU-R M.2078, have illustrated with two values, for low density and for high density. We are here discussing the impacts of market parameters with different values. So that the study groups can judge the importance and use of these parameters on spectrum calculation requirements.we are analyzing the required spectrum by 2015 and 2020 with the possible values of *user density (U) , session arrival rate per user (Q), Average session duration (μ) and mean service bit rate (r)*. As we know that the number of mobile users is increasing, and in urban and sub urban areas user density is also increasing. The session arrival rate per user is also be a very important factor here, when we are discussing for the future requirement of the required spectrum, because it will increase as the load or traffic increased. But users always want to connect within a fixed time session.This paper will present the possible adjustment of these important factors of market data on the spectrum requirement.

2. MARKET PARAMETERS IN THE METHODOLOGY
The ITU spectrum calculation methodology uses a limited set of market study parameters to characterize the future wireless services. The market study parameters characterize the demand of twenty different service categories (SC 1-20) in six service environments (SE 1-6) in three forecast years. The parameter values are given separately for uplink and downlink transmission directions as well as for unicast and multicast traffic. The market-related input parameters for the spectrum calculation methodology including the following parameters :

- User density
- Session arrival rate per user
- Average session duration
- Mean service bit rate
- Mobility ratio

2.1 User density
The user density $U_{m,n}$ (users/km^2) of service category n in service environment m is calculated as the summation of the user density of each service mapped into this service category according to

$$U_{m,n} = \sum_{s \in n} U_{m,s}$$

Where $U_{m,s}$ (users/km^2) denotes the user density of service s inside service category n in service environment m.

2.2 Session arrival rate per user
The session arrival rate per user $Q_{m,n}$ (session/s/user) of service category n in service environment m is the weighted average of session arrival rate per user of each service mapped into this service category. The weight of each session is the corresponding user density of the service, i.e. Um,s. The session arrival rate per user is the calculated from

$$Q_{m,n} = \frac{\sum_{s \in n} U_{m,s} Q_{m,s}}{U_{m,n}} \qquad (2)$$

Where $Q_{m,s}$ (sessions/s/user) denotes the session arrival rate per user of service s inside service category n in service environment m.

2.3 Average session duration

The average session duration $\mu_{m,n}$ (s/session) of service category n in service environment m is the weighted average of average session duration of each service mapped into this service category. The weight is the session arrival rate per area unit, i.e. the product of the user density ($U_{m,n}$) and the session arrival rate per user ($Q_{m,n}$). The average session duration is calculated from

$$\mu_{m,n} = \sum_{s \in n} \omega_{m,s} \mu_{m,s} \qquad (3)$$

Where $\mu_{m,n}$ (s/session) denotes the average session duration of service s inside service category n in service environment m. The weight $\omega_{m,s}$ (dimensionless) is obtained from

$$\omega_{m,s} = \frac{U_{m,s} Q_{m,s}}{U_{m,n} Q_{m,n}}, \quad s \varepsilon n \qquad (4)$$

2.4 Mean service bit rate

The mean service bit rate $r_{m,n}$ (bit/s) of service category n in service environment m is the weighted average of the mean service bit rate of each service mapped into this service category. The weight is the traffic volume per area unit, i.e. the product of the session arrival rate per unit ($U_{m,n}Q_{m,n}$) and the average session duration ($\mu_{m,n}$). The mean service bit rate is calculated from

$$r_{m,n} = \sum_{s \in n} \varpi_{m,s} r_{m,s}$$

Where $r_{m,n}$ (bit/s) denotes the mean service bit rate of service s inside service categories n in service environment m. The weight $\varpi_{m,s}$ (dimensionless) is obtained from

$$\varpi_{m,s} = \frac{U_{m,s} Q_{m,s} \mu_{m,s}}{U_{m,n} Q_{m,n} \mu_{m,n}}, s \in n \qquad (6)$$

2.5 Mobility ratios

The calculation of the mobility ratios involves two stages.In the first stage , the market study mobility ratio

$$MR_{m,n}^{Market}$$

(dimensionless) of service category n in service environment m is calculated as the weighted average of the mobility ratio

$$MR_{m,s}^{Market}$$

(dimensionless) of each service s inside service category n in the same service environment m. The weight is

the traffic volume per area unit as in the case of the mean service bit rate. Thus the mobility ratios are calculated from

$$MR_{m,n}^{Market} = \sum_{s \in n} \varpi_{m,s} MR_{m,s}^{Market} \qquad (7)$$

Where the weight $\varpi_{m,s}$ is given in Eq. (6). The equation can be applied to all mobility classes, i.e. stationary, low , high and super-high classes for each service category and service environment.

In the second stage, the market study mobility ratios per service category and service environment obtained from Equation (7) for stationary, low, high, and super-high mobility classes need to be mapped into the methodology mobility ratios for stationary/pedestrian, low and high mobility classes. The mapping is done with the splitting factor J_m, which is given in the figure(1) below.

Mobility in market studies	Mobility in methodology
Stationary	Stationary / Pedestrian
Low	
High	Low (fraction *Jm*)
	High (fraction 1 - *Jm*)
Super high	

Figure 1 : Mapping of mobility classes from market study to methodology

Thus the mobility ratio for the stationary/pedestrian mobility class of service category n in service environment m in the spectrum calculation methodology is obtained from

$$MR_{stat/\,ped;m,n} = MR_{stat;m,n}^{Market} + MR_{low;m,n}^{Market} \qquad (8)$$

The mobility ratio for the low mobility class of service category n in service environment m in the spectrum calculation methodology is obtained from

$$MR_{low;m,n} = J_m MR_{high;m,n}^{Market} \qquad (10)$$

Finally, the mobility ratio for the high mobility class of service category n in service environment m in the spectrum calculation methodology is obtained from

$$MR_{high;m,n} = (1 - J_m) MR_{high;m,n}^{Market} + MR_{s-high;m,n}^{Market} \qquad (11)$$

Hence the following relation should be clear:

$$MR_{stat/\,ped;m,n} + MR_{low;m,n} + MR_{high;m,n}$$

$$= MR_{stat;m,n}^{Market} + MR_{low;m,n}^{Market} + MR_{high;m,n}^{Market} + MR_{s-high;m,n}^{Market} \qquad (12)$$

for each service category n and market environment m.

3. ANALYSIS OF COLLECTED MARKET DATA

The market data analysis uses the notion of application and services. A service is the basis element which builds up the applications. An application is a higher level definition to categories the collected services. An application may consist of several services that occur independently.

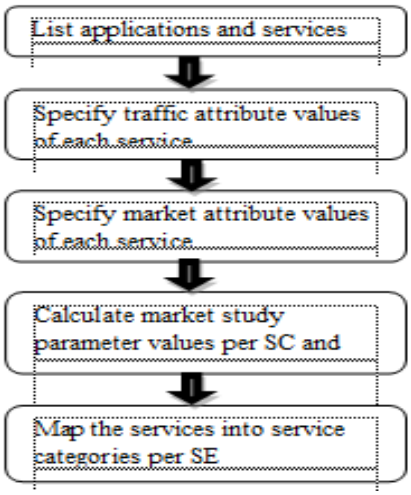

Figure 2: General process for the market data analysis

4. SPECTRUM REQUIREMENTS OF THE IMT-RELATED RAT GROUPS

There are expected to be regional differences in the market development, i.e. and some parts of the world a particular level of market development may be reached earlier or later than in the (average) "global common market". In the table 1, Spectrum requirement calculation is done with the fixed values for the three variables session arrival rate per user (Q), Mean service bit rate (R), and Average session duration (μ) at 30. The variation is done on the variable user density (U) for the values 15-45. The figure 3 is shows the impacts of the variation in user density on the total spectrum requirement.

The spectrum requirements are calculated for RAT Group 1 (i.e. pre-IMT, IMT-2000, and its enhancements) and RAT Group 2 (i.e. IMT-Advanced) in 2010, 2015 and 2020. The spectrum requirements are calculated with the time shift approach described above using the input parameter. The input parameter values are used to calculate the spectrum requirements for default "middle" scenario. The results for "later" and "earlier" scenario are derived by shifting the results from the "middle scenario".

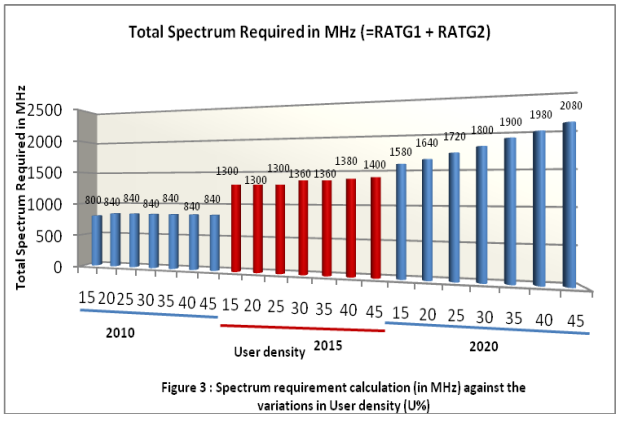

Figure 3 : Spectrum requirement calculation (in MHz) against the variations in User density (U%)

Table 1 : Total Spectrum Requirement in MHz with different user density values

Year	User density (U%)	Spectrum Required in MHz for each RATG		Total Spectrum Required in MHz (=RATG1 + RATG2)
		RATG1	RATG2	
2010	15	800	0	800
	20	840	0	840
	25	840	0	840
	30	840	0	840
	35	840	0	840
	40	840	0	840
	45	840	0	840
2015	15	880	420	1300
	20	880	420	1300
	25	880	420	1300
	30	920	440	1360
	35	920	440	1360
	40	920	460	1380
	45	920	480	1400
2020	15	880	700	1580
	20	880	760	1640
	25	880	840	1720
	30	880	920	1800
	35	920	980	1900
	40	920	1060	1980
	45	960	1120	2080

In the Table 2 given below, we have calculated the total spectrum requirement by varying the values for the another variable session arrival rate per user (Q) for the values 15-60 and keeping the other variables U, R and μ at constant values on 25 (higher density) , 30, and 30 respectively. The figure 4 shows the impacts of the variation in session arrival rate per usre on the total spectrum requirement.

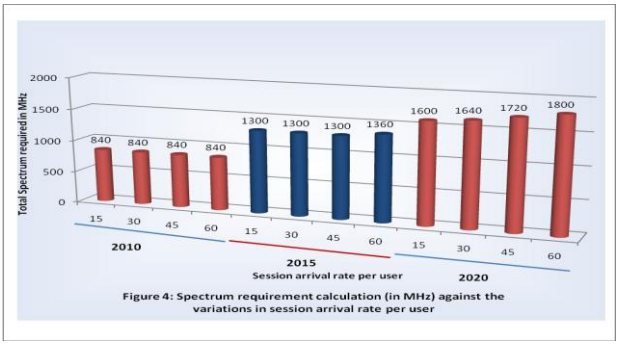

Figure 4: Spectrum requirement calculation (in MHz) against the variations in session arrival rate per user

Table 2: Total Spectrum Requirement in MHz with different Session arrival rate per user values

Year	Session arrival rate per user (Q%)	Spectrum Requirement in MHz for each RATG		Total Spectrum requirement in MHz (=RATG1+RATG2)
		RATG1	RATG2	
2010	15	840	0	840
	30	840	0	840
	45	840	0	840
	60	840	0	840
2015	15	880	420	1300
	30	880	420	1300
	45	880	420	1300
	60	920	440	1360
2020	15	880	720	1600
	30	880	760	1640
	45	880	840	1720
	60	880	920	1800

Table 3: Total Spectrum Requirement in MHz with different Mean Service bit rate (R) values

Year	Mean Service bit rate (R%)	Spectrum Requirement in MHz for each RATG		Total Spectrum Required in MHz (=RATG1 + RATG2)
		RATG1	RATG2	
2010	20	800	0	800
	30	840	0	840
	40	840	0	840
	50	840	0	840
2015	20	880	420	1300
	30	880	420	1300
	40	920	460	1380
	50	920	580	1500
2020	20	840	740	1580
	30	880	840	1720
	40	920	940	1860
	50	960	1160	2120

In table 3, we calculate the total spectrum required on the variation of R i.e. Mean service bit rate for the values R = 20 -50 Mbps and figure 5 shows the results.

In table 4, we calculate the total spectrum required on the variation of μ i.e. Average session duration for the values R = 20 -60 Mbps and figure 6 shows the results.

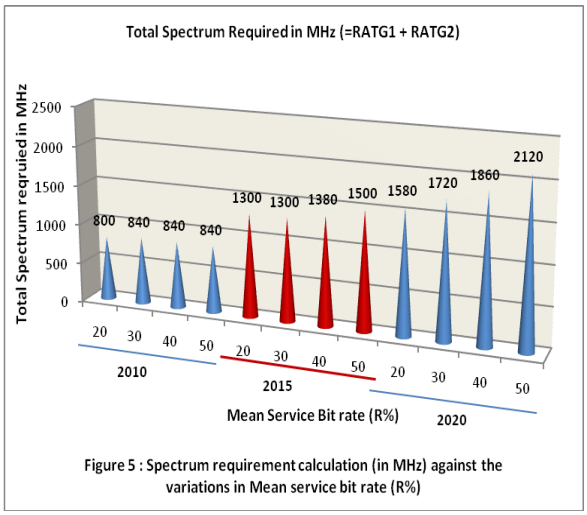

Figure 5 : Spectrum requirement calculation (in MHz) against the variations in Mean service bit rate (R%)

Table 4: Total Spectrum Requirement in MHz with different

Year	Average session duration (μ%)	Spectrum Requirement in MHz for each RATG		Total Spectrum Required in MHz (=RATG1 + RATG2)
		RATG1	RATG2	
2010	20	840	0	840
	30	840	0	840
	40	840	0	840
	50	840	0	840
	60	840	0	840
2015	20	880	420	1300
	30	880	420	1300
	40	920	440	1360
	50	920	460	1380
	60	920	480	1400
2020	20	880	780	1660
	30	880	840	1720
	40	880	900	1780
	50	920	980	1900
	60	960	1040	2000

Average session duration (μ) values

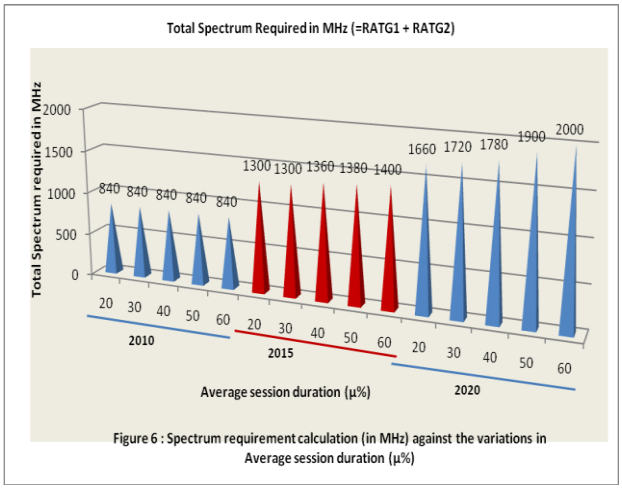

Figure 6 : Spectrum requirement calculation (in MHz) against the variations in Average session duration (μ%)

5. CONCLUSION

This paper presents the results of the calculation of spectrum requirement for RAT Group 1 (i.e. pre-IMT, IMT-2000, and its enhancements) and RAT Group 2 (i.e. IMT-Advanced) in 2010, 2015, and 2020.

In this paper, we uses the spectrum calculation methodology presented in the Recommendation ITU-R M.1768 and defines values for all the input parameters needed for spectrum calculations. The spectrum requirements have been calculated for two RAT Groups in the years 2010, 2015, and 2020.

We have shown the impacts of market input parameters , User density (U), session arrival rate per user (Q), Mean service bit rate (R) and Average session duration (μ) for its different possible values , on the spectrum requirement for RATG1 and RATG2. As different countries have different geographical conditions and technology implemented. Hence they have different market input parameters. In this paper we have presented these variations, so that it can be estimated for different conditions.

6. ACKNOWLEDGEMENT

We are grateful to our colleagues and friends, who have supported us directly or indirectly to complete this work. The authors like go give thanks to Er. Anil Singh, Chancellor, Bhagwant University, Ajmer for their constant support.

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