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METIS Propagation Scenarios

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METIS Propagation Scenarios

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Abstract: **In this TD we report METIS propagation scenarios based on an internal deliverable IR1.3. The final METIS models are not defined yet, and the propagation research in METIS project will provide input for the final channel models.**

1. INTRODUCTION

The overall goal of the METIS project is to lay the foundation for the beyond 2020 5G mobile and wireless communication systems by providing the technical enablers needed to address the requirements foreseen for this time frame [1], [2]. This will realize the METIS vision of a future where access to information and sharing of data is available *anywhere* and *anytime* to *anyone* and *anything*. In METIS' vision about the future information society private and professional users will be provided with a wide variety of applications and services, ranging from infotainment services, through increased safety and efficient usage of transportation, to completely new industrial and professional applications. This vision results in challenges such as the very high data rates, and the very dense crowds of users, with higher requirements on the end-to-end performance and user-experience. New types of challenges that arise from new application areas are the very low latency, and the very low energy, cost, and massive number of devices. As a consequence, the METIS overall technical goal provides a system concept that, relative to today, would support:

- 1000 times higher mobile data volume per area,
- 10 times to 100 times higher number of connected devices,
- 10 times to 100 times higher typical user data rate,
- 10 times longer battery life for low power Massive Machine Communication (MMC) devices,
- 5 times reduced End-to-End (E2E) latency,

at a similar cost and energy consumption as today's networks.

The above goal set new requirements to channel models.

The METIS channel modelling process is depicted in Figure 1. Requirements come from other work packages and the public available deliverable on 5G scenarios D1.1 [2] of METIS [1]. The corresponding propagation scenarios are defined in this document specifying required modelling of backhaul, BS-MS, or Device-to-Device (D2D) type of links. Multi-dimensional propagation effects, i.e. dispersion in time, frequency, space, and polarization domains, have to be accounted for in the METIS channel modelling. Propagation data from a set of measurements, ray tracing simulations, and literature reviews is analyzed. Parameters are defined based on the analysis, and the parameters are applied to the channel model framework.

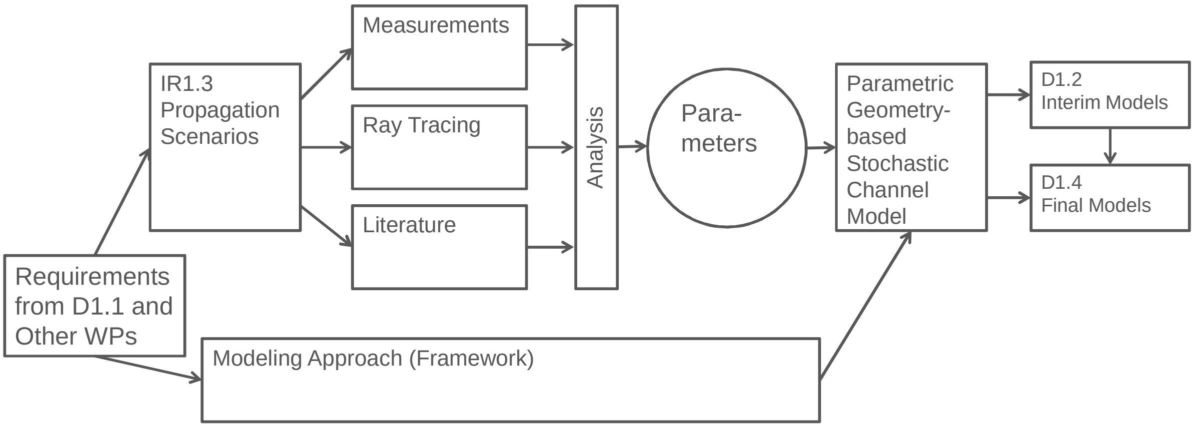

Figure 1. METIS Channel Modeling Process.

The final METIS channel models will be published in METIS Deliverables D1.2 "Initial channel models based on measurements" in April 2014 and D1.4 "METIS channel models" in February 2015. This TD identifies the important channel propagation scenarios based on recently published METIS Deliverable D1.1 [2] and on the Internal Report IR1.3 [3].

2. METIS SCENARIOS AND TEST CASES

The METIS work is specified in five generic scenarios each describing the specific challenge of the coming 5G mobile systems [1]. The scenarios and the corresponding challenges are:

- **Scenario 1**: Amazingly fast to reflect the very high data rate challenge
- **Scenario 2**: Great service in a crowd to address the challenge of very dense crowds of users
- **Scenario 3**: Ubiquitous things communicating to represent very low energy, cost, and a massive number of devices challenge
- **Scenario 4**: Best experience follows you to address the mobility challenge
- **Scenario 5**: Super real-time and reliable connections to set the very low latency challenge

Furthermore, twelve test cases (TCs) are defined to cover the practical applications of 5G system and simulation needs in METIS for the coming 5G system [1]. A TC may belong to different scenarios, which may affect the details of the TCs but preserve the main content of the TCs. The METIS TCs are listed in Table 1 below:

Table 1. METIS Test Cases.

TC#	METIS Test Case
1	Virtual Reality Office
2	Dense Urban Information Society
3	Shopping Mall
4	Stadium
5	Teleprotection in smart grid network
6	Traffic Jam
7	Blind Spots
8	Real-Time Remote Computing for Mobile Terminals
9	Open Air Festival
10	Emergency Communications
11	Massive Deployment of Sensors and Actuators
12	Traffic Efficiency and Safety

The mapping of the five scenarios to twelve test cases is detailed in [1].

3. METIS PROPAGATION SCENARIOS

Since the final frequency bands in METIS simulations are not yet known, both below 6 GHz bands and above 6 GHz bands are investigated. Measurement capability is limited and we need to apply a cautious interpolation and extrapolation. However, extrapolation for the whole frequency range from 6 GHz to 60 GHz is not possible without several measurement samples from different frequency bands. Therefore in the initial channel modeling phase we limit the choices to 450 MHz - 6 GHz and around 60 GHz. Table 2 shows initial frequency ranges of Propagation Scenario Sets for each Test Case. It would also be very interesting to measure several different bands between 6 and 60 GHz range, but due to the limitations of channel sounder equipment, it will be quite challenging.

Table 2. Initial Frequency Ranges of Propagation Scenario Sets for Each TC.

TC#	**METIS Test Case**	**450 MHz - 6 GHz**	**60 GHz**
1	Virtual Reality Office	yes	yes
2	Dense Urban Information Society	yes	yes
3	Shopping Mall	yes	yes
4	Stadium	yes	
5	Teleprotection in smart grid network	yes	
6	Traffic Jam	yes	
7	Blind Spots	yes	
8	Real-Time Remote Computing for Mobile Terminals	yes	
9	Open Air Festival	yes	yes
10	Emergency Communications	yes	
11	Massive Deployment of Sensors and Actuators	yes	
12	Traffic Efficiency and Safety	yes	yes

Basic propagation environments and link types are defined as shown in Table 3 and Table 4, respectively.

Table 3. Propagation Environments.

#	**Propagation Environment**
1	Urban Macrocell
2	Urban Microcell
3	Suburban (may be removed)
4	Rural
5	Indoor Office
6	Indoor Shopping Mall
7	Highway
8	Stadium

Table 4. Link Types.

Abbr.	**Link Type**
O2O	Outdoor to outdoor link
O2I	Outdoor to indoor link
I2I	Indoor to indoor link
ST	Stadium

Based on the above definitions, the METIS Propagation Scenarios are shown in the Table 5. D2D stands for Device-to-Device communications including any direct link between mobile devices (e.g. human-to-human, machine-to-machine, vehicle-to-vehicle), BS-MS means any link from a fixed station to mobile station (e.g. BS-to-mobile, relay-to-mobile), and backhaul means any fixed connection (e.g. BS-RS, BS-BS, BS-CN).

Table 5. METIS Propagation Scenarios.

Below 6 GHz			**Above 6 GHz**		
D2D	BS-MS	Backhaul	D2D	BS-MS	Backhaul
Urban O2O (also V2V)	Urban Micro O2O	Urban Micro O2O		Urban Micro O2O	
Urban O2I	Urban Micro O2I				
	Urban Macro O2O	Urban Macro O2O			Urban Macro O2O
	Urban Macro O2I				
Rural O2O	Rural O2O	Rural O2O		Rural O2O	Rural O2O
Rural O2I	Rural O2I				
Indoor Office	Indoor Office	Indoor Office		Indoor Office	
Indoor Shopping mall	Indoor Shopping mall	Indoor Shopping mall		Indoor Shopping mall	Indoor Shopping mall
Highway V2V			Highway V2V		
Crowd D2D	Stadium O2O	Urban Macro (LOS)			

3.1.1 Mapping between Propagation Scenarios and Test Cases.

Table 6. Mapping of Propagation Scenarios on Test Cases (sub-6 GHz)).

		Test Case											
		1	2	3	4	5	6	7	8	9	10	11	12
BS-MS	Urban Micro O2O		y		4a	y	y	y			10a		y
	Urban Micro O2I	y	y								y		y
	Urban Macro O2O		y		4c	y	y	y	y		10a		y
	Urban Macro O2I		y	y							y		y
	Rural O2O					y	y	y	y	y	10a		
	Indoor Office	y	y										
	Indoor Shopping mall			y									
D2D	Urban O2O (also V2V)		y		4b			y				y	y
	Urban O2I	y	y										y
	Rural O2O									y	10a	y	
	Indoor Office	y	y										
	Indoor Shopping mall			y								y	
	Highway V2V						y						y
Backhaul*	Urban Micro O2O		y										
	Urban Macro O2O		y										
	Rural O2O										y		
	Indoor Office		y										
	Indoor Shopping mall			y									

* backhaul means any fixed connection BS-RS, BS-BS, BS-CN
* 4a UMi O2O for stadium
* 4b Urban D2D for stadium
* 4c UMa O2O (LOS) for stadium backhaul
* 10a UMa/UMi/Rural O2O added with rubble attenuation for buried victims

Table 7. Mapping of Propagation Scenarios on Test Cases (60 GHz).

		Test Case											
		1	2	3	4	5	6	7	8	9	10	11	12
BS-MS	Urban Micro O2O		y										
	Indoor Office	y	y										
	Indoor Shopping mall			y									
	Rural O2O									y			
D2D	Urban O2O (also V2V)												
	Indoor Office												
	Indoor Shopping mall												
	Highway V2V												y
Backhaul*	Urban Micro O2O												
	Urban Macro O2O		y										
	Suburban O2O												
	Rural O2O									y			
	Indoor Office												
	Indoor Shopping mall			y									

* backhaul means any fixed connection BS-RS, BS-BS, BS-CN

4. BS-MS SCENARIOS

In this category of link types the MS is assumed to be a user device, machine, sensor, or vehicle, which may be moving or stays fixed for the time period of interest. The device is usually connected to the Internet via BS-MS link only.

4.1.1 Urban Micro O2O

It is assumed that the access point antennas are located well below rooftop level (1.5-10m height). A Manhattan grid type of environment is assumed which is extending substantially also in the vertical dimension wherefore 3D modeling is required. The MS velocity is assumed to be in the range 0-50 km/h.

4.1.2 Urban Micro O2I

In this scenario BS is located below rooftops, typically at 1.5-15 m depending on the height of surrounding buildings. The geometry of the outdoor environment is assumed to be Manhattan grid like layout. Mobile stations may be located on the different floors of buildings.

The radio wave propagation can be divided into outdoor propagation, penetration through the wall and indoor propagation. Since users can be located on different floors, the path loss and shadowing model should be determined in 3D coordinates in the final METIS channel model.

4.1.3 Urban Macro O2O

It is assumed that the BS antennas are located above surrounding building heights. 3D modeling and 3D distribution of MSs are required. The MS velocity is assumed to be in the range of 0-50 km/h.

4.1.4 Urban Macro O2I

Urban macro cell outdoor-to-indoor propagation environment is similar to urban macro-cell O2O. In O2O propagation the mobile stations are typically located at street level, whereas in O2I scenario the mobile stations may be more widely distributed in elevation domain as they may be located on different floors inside of buildings. The typical BS antenna placement in an urban macro cell is above the rooftop level and therefore the typical outdoor propagation until the building wall may include quite long LOS path and often one or more diffractions over the rooftops. The diffraction angle to lower floors is typically higher and therefore the path loss is higher. The penetration loss through the walls or windows may also be higher in lower floors as the diffracted ray hits the wall or window with higher elevation angle (the penetration loss increases when the angle of incidence is small relative to the exterior wall).

The path loss and shadowing model should take different MS heights into account. The penetration loss through the wall is dependent on the wall thickness and material and the propagation through the window plays an important role in this scenario. Due to these reasons the type of the building should be defined. In old buildings with normal glass windows, the window penetration loss may be remarkably lower than in modern buildings due to thick safety glass or metal-coated windows.

4.1.5 Rural O2O

It assumed that this scenario represents radio propagation in large areas (radii up to 10km) with low building density, and the height of the BS antenna is typically in the range of 20-70 m, which is much higher than the average building height. 3D modeling is required. The MS velocity is assumed to be in the range of 0-250 km/h.

4.1.6 Rural O2I

BS antenna heights are in the range of 10-100 m, which is well above the average height of buildings in rural environments. LOS probability from BSs to building walls is high due to wide open areas and low building heights. However, depending on geographical location there might be heavy vegetation (forest) and/or hilly terrain resulting in low probability of LOS. The penetration loss through the wall is assumed to be several tens of decibels due to collapsed buildings in TC10.

4.1.7 Indoor Office

It is assumed that the access point antennas are located between 1.5 m above the floor and up to the ceiling level. This topology requires 3D modeling because the users as well as the access points may be distributed over different floors in a single building and/or in different buildings. The MS velocity is assumed to be in the range of 0-3 km/h.

4.1.8 Indoor Shopping mall

The shopping mall propagation scenario consists of an open space which is surrounded by smaller rooms, e.g. shops. The open space usually contains some obstructions such as catering areas and escalators. Additionally it may be multiple floor levels high with several shops located on different floors.

The indoor BSs are placed on elevated structures (maybe above 2 m) on each floor of the shopping mall in order to increase LOS probability. MS heights are assumed to be in the range of 0.5-1.5 m on each floor and the distance between BS and MS is 1-30 m or longer depending on the mall size. In open space, it is assumed that there are reflected multi-paths with rather long delays compared to indoor closed space. The movement of MSs is quite slow and the speed varies from 0 km/h (catering area and inside shops) to 3 km/h (walking space and gallery). Additional loss caused by human body shadowing may need to be considered when the shopping center is crowded. Body effects are, however, missing in the initial channel models. Such effects can be modeled earliest in the intermediate or final METIS models.

The penetration and diffraction loss through concrete walls as well as glass windows/doors may need to be considered, when interference between indoor and outdoor users has to be taken into account.

5. D2D SCENARIOS

D2D is a direct connection between two mobile devices. We consider D2D as any device-to-device communication, e.g. human-to-human (H2H), vehicle-to-vehicle (V2V), vehicle-to-human (V2H) and machine-to-machine (M2M). As described in [3], D2D is considered in eight different propagation scenarios. It was recognized from literature that geometric D2D models are generally not available.

Most propagation research has been concentrating on the link between base and mobile stations. The D2D propagation model should be compatible with the corresponding cellular channel model so that comparison of these two technologies is fair, which means that the channel model should not bias the comparison results by giving unjustified advantage to either of these technologies.

D2D propagation differs from cellular in two ways. In D2D both terminals are typically low at the street level, and both terminals can be moving. This has implications in propagation. Path loss typically is higher than in cellular case and LOS is less likely at a given distance. The link is symmetric, so both Tx and Rx see a similar environment, and should have similar distributions for all parameters. Ensuring unbiased comparisons, this means that the cellular and D2D models should be identical if the BS height is equal to the MS height except for the fact that both ends of the D2D link may be moving.

For simplicity we will specify the D2D channel models as special cases of the cellular 3D channel models. Statistical distributions like angular spreads need to be equal at both ends of the link. We recommend using those from low antenna height. The choice to create the D2D models from the cellular models also brings the desired correlation properties into D2D use. Reliable measurement and ray-tracing results are lacking at the moment. During the project these parameters will be based on measurement and/or ray-tracing results from METIS and other sources.

D2D is defined for Urban O2O, Urban O2I, Rural O2O, Rural O2I, Indoor Office I2I, Indoor Shopping Mall I2I, and Highway O2O.

6. BACKHAUL SCENARIOS

Backhaul link (any link between BS-BS, BS-RS, BS-CN) is considered for the following propagation scenarios: Urban Micro O2O, Urban Macro O2O, Rural Macro O2O, and Indoor Office.

7. DISCUSSION AND CONCLUSIONS

This TD presentsthe METIS propagation scenarios. Final channel models are not defined yet. Any input for the final channel models from COST IC1004 would be appreciated.

8. REFERENCES

[1] METIS web site http://www.metis2020.com/

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[3] T. Jämsä, H. Taoka, J. Meinilä (Editors), ”Propagation scenarios and framework of channel model,” Internal Report IR1.3, ICT-317669-METIS, 31/05/2013.