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工業技術研究院
Industrial Technology
Research Institute

WiSE 系統層級模擬器

Wireless Simulator Evolution

工研院資通所
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2016.03.28

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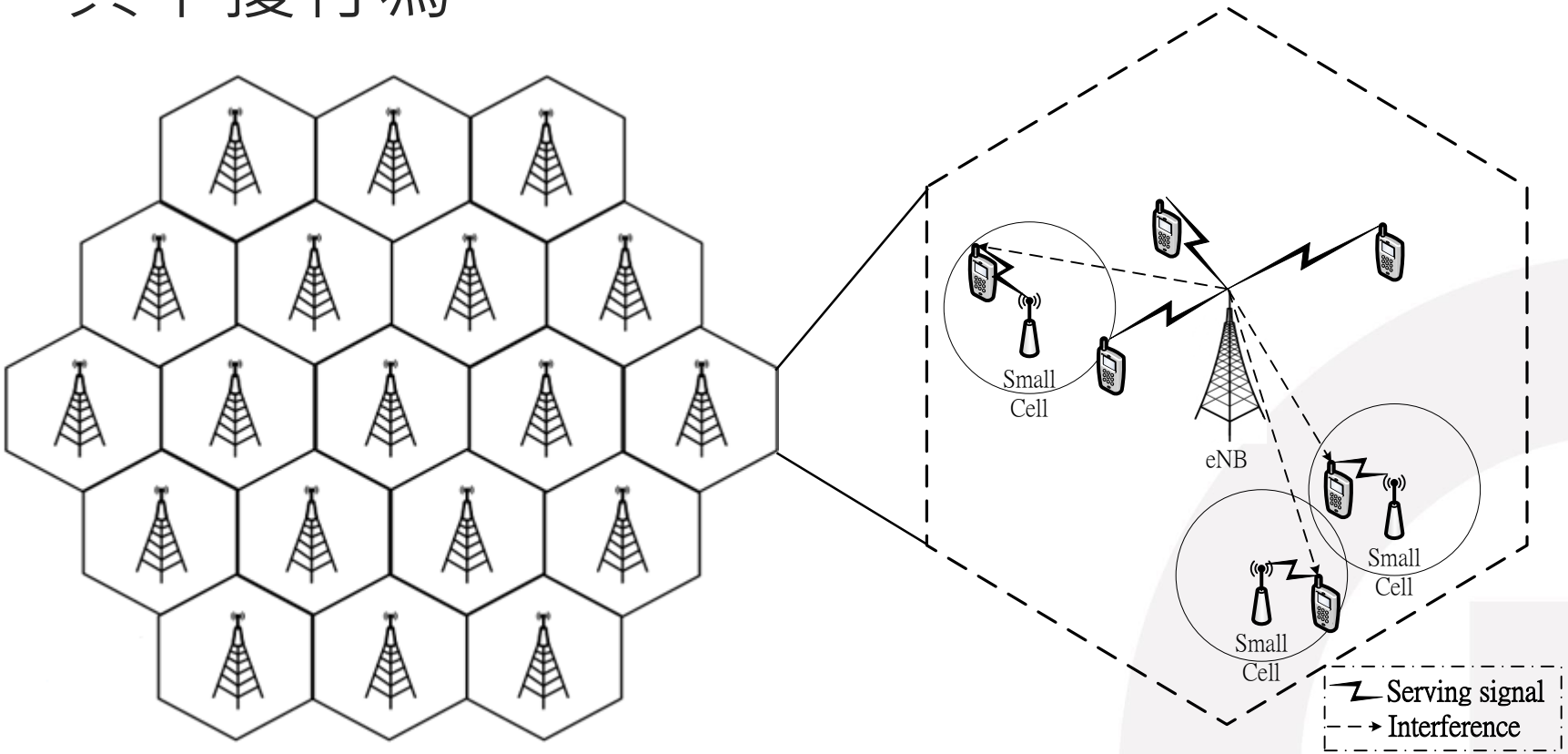
Outline

- 何謂系統層級模擬器?
- WiSE模擬器功能介紹
- The **FACT** of WiSE
- 總結

系統層級模擬器 – What?

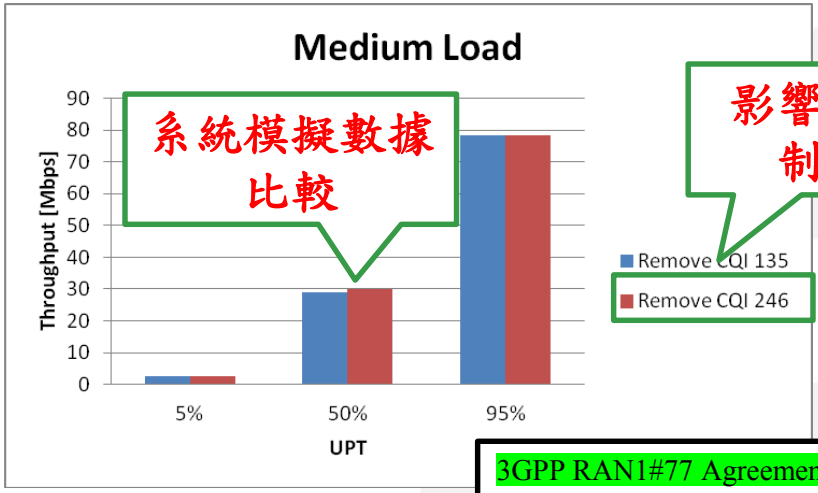
- 系統層級模擬器模擬大量基站與更大量 的使用者設備之間錯綜複雜的排程、互動、傳送與干擾行為。



系統層級模擬器 – Need

- 需求
  - 研究通訊技術在整體網路上的效果
  - 協助產品開發
  - 影響標準制定方向
  - 提供客戶效能佐證數據

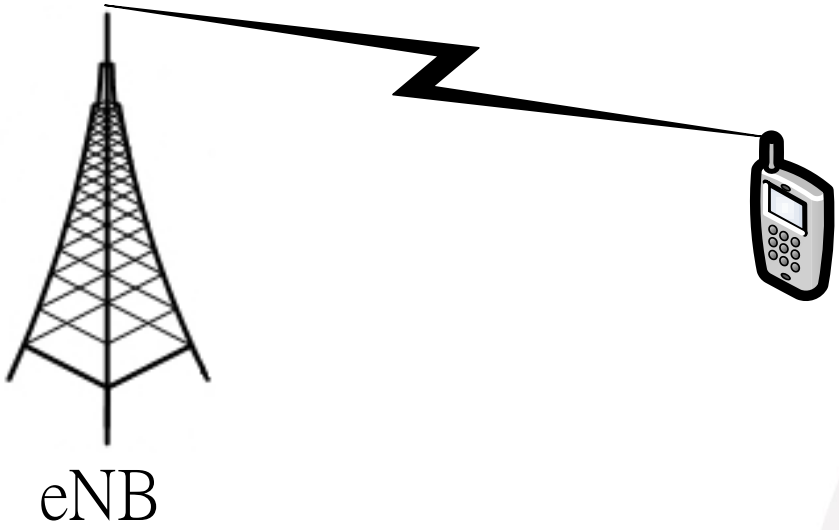
3GPP RAN1 Study Item	TDD eIMTA干擾管理及流量適應
總提案數	126
具模擬數據的提案數	95



3GPP RAN1#77 Agreement:
- The 3 QPSK entries to be removed are existing {#2, #4, #6}

系統層級模擬器 – Why not? (1/2)

☹傳統線路級模擬器僅模擬單一收送設備間的傳送行為，無法了解干擾影響。



系統層級模擬器 – Why not? (2/2)

☹訊號覆蓋工具僅可獲得概要的訊號強度，無法了解流量影響、使用者封包吞吐量、延遲、公平性等數據。

系統層級模擬器 – Objective

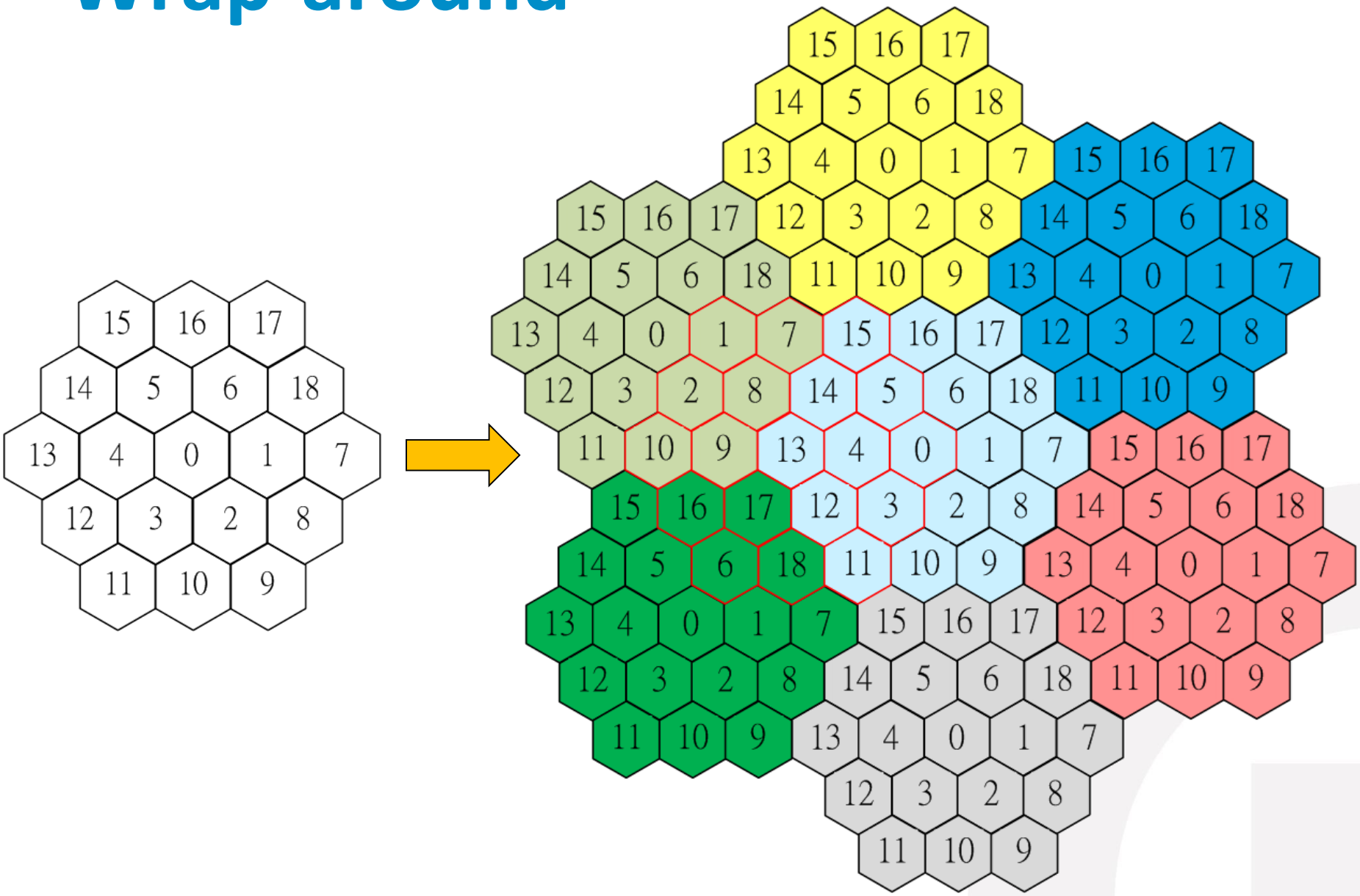
- ✓系統層級模擬器模擬大量基站與更大量 的使用者設備之間錯綜複雜的排程、互動、傳送與干擾行為。
  - 可了解無線網路系統下大量的基站與大量的使用者設備在各種技術下，基地台的平均傳輸速率、流量影響、使用者封包吞吐量、延遲、公平性等數據。

WiSE 功能介紹

WiSE 系統層級模擬器 – 特點

- 軟體需求: 只需要C++ compiler (GCC)
- 可模擬 LTE FDD system 與 LTE TDD system
- 具模擬 downlink 與 uplink 功能
- 根據closed-loop CSI feedback的結果進行排程 (e.g., Proportional fair, FIFO, and round-robin)
- Adaptive transmission mode based on channel capacity

Wrap-around



WiSE 系統層級模擬器 – How? (1/2)

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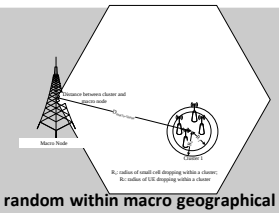
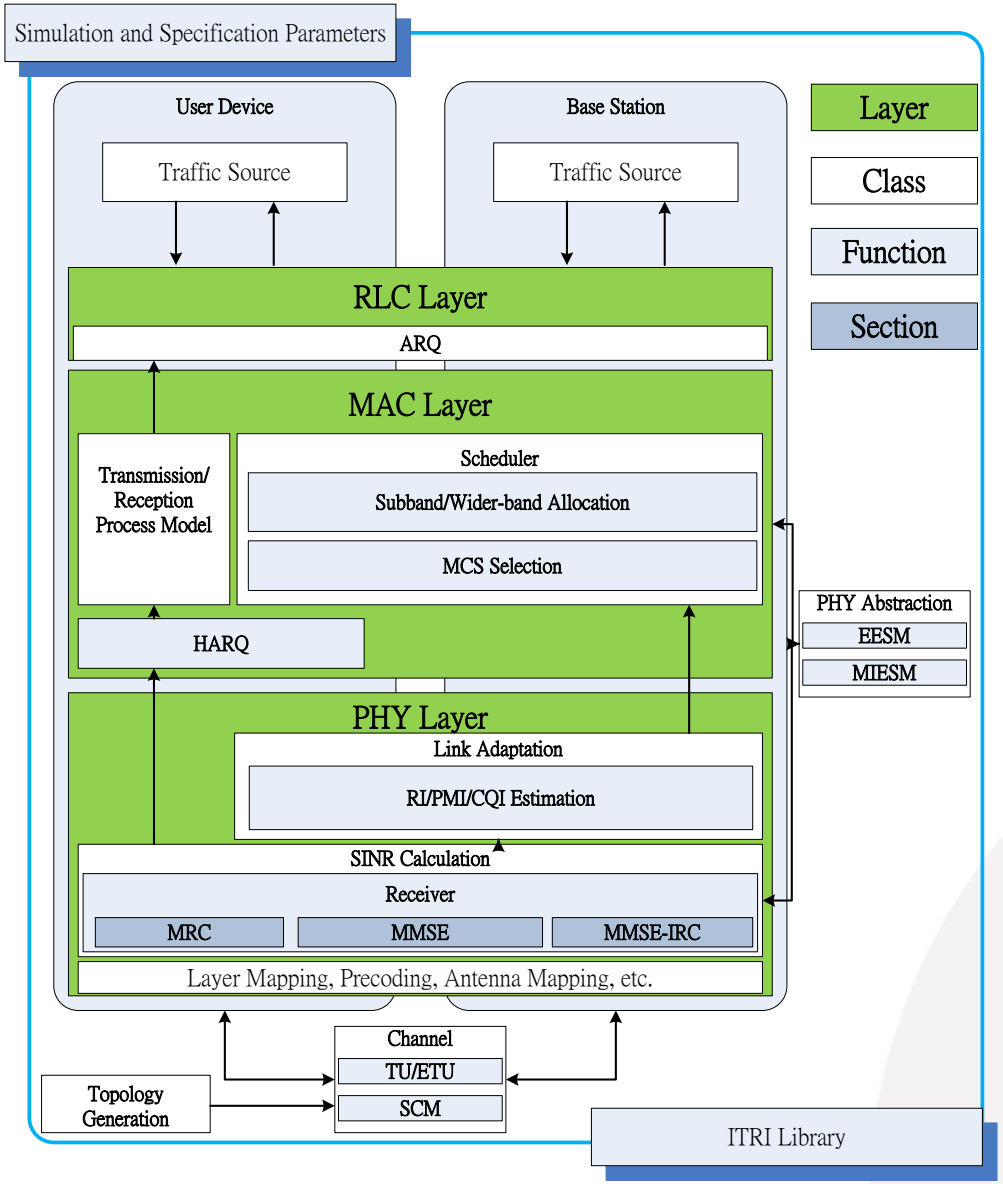
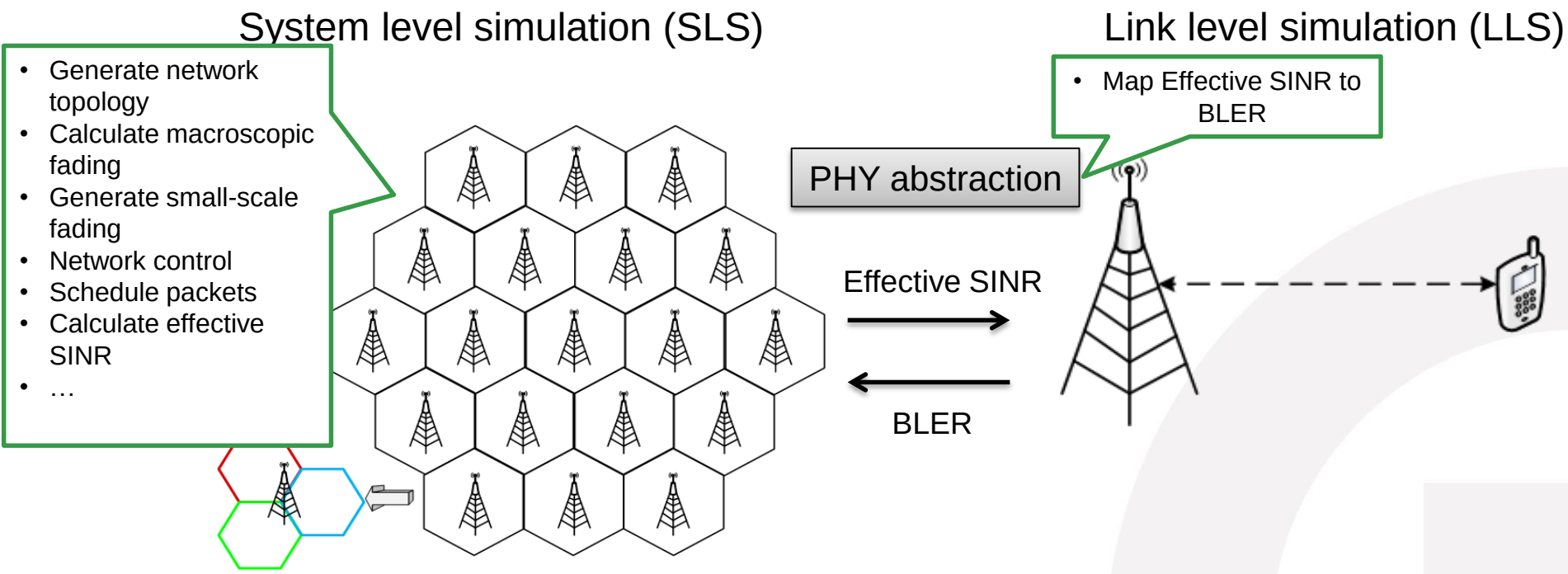
	Macro cell	Small cell
Layout	Hexagonal grid, 3 sectors per site, case 1 Both 19 Macro sites and 7 Macro sites can be used. Companies should indicate whether 19 or 7 sites are used when presenting the results.	 Clusters uniformly random within macro geographical area; small cells uniformly random dropping within cluster area
System bandwidth per carrier	10MHz	10MHz
Carrier frequency	2.0GHz	2.0GHz
Carrier number	1	1
Total BS TX power (Ptotal per carrier)	46dBm	30 dBm, Optional: 24dBm, 37dBm
Distance-dependent path loss	ITU UMa[referring to Table B.1.2.1-1 in TR36.814], with 3D distance between an eNB and a UE applied. Working assumption is that 3D distance is also used for: break point distance	ITU Umi [referring to Table B.1.2.1-1 in TR36.814] with 3D distance between an eNB and a UE applied Working assumption is that 3D distance is also used for: break point distance
Penetration	For outdoor UEs:0dB For indoor UEs: 20dB+0.5d_{in} (d_{in} : independent uniform random value between [0, min(25,d)] for each link)	For outdoor UEs:0dB For indoor UEs: 20dB+0.5d_{in} (d_{in} : independent uniform random value between [0, min(25,UE-to-eNB distance)] for each link)
Shadowing	ITU UMa according to Table A.1-1 of 36.819 Working assumption is that 3D distance is used for shadowing correlation distance	ITU UMi[referring to Table B.1.2.1-4 in TR36.814] Working assumption is that 3D distance is used for shadowing correlation distance
Antenna pattern	3D, referring to TR36.819	2D Omni-directional is baseline; directional antenna is not precluded
Antenna Height:	25m	10m
UE antenna Height	1.5m	
Antenna gain + connector loss	17 dBi	5 dBi
Antenna gain of UE	0 dBi	
Fast fading channel between eNB and UE	ITU UMa according to Table A.1-1 of 36.819	ITU Umi
Antenna configuration	2Tx2Rx in DL, Cross-polarized	
Number of small cells per cluster	4, 10	
Number of small cells per Macro cell	[4,10]*Number of clusters per macro cell geographical area	
Number of UEs	60 UEs per macro cell geographical area are recommended when FTP model 3 is used	
UE dropping	Baseline: 2/3 UEs randomly and uniformly dropped within the clusters, 1/3 UEs randomly and uniformly dropped throughout the macro geographical area. 20% UEs are outdoor and 80% UEs are indoor.	
Radius for small cell dropping in a cluster	50m	
Radius for UE dropping in a cluster	70m	
Minimum distance (2D distance)	Small cell-small cell: 20m Small cell-UE: 5m Macro –small cell cluster center: 105m Macro – UE : 35m cluster center-cluster center: 2*Radius for small cell dropping in a cluster	
Traffic model	FTP1 or FTP3	
UE receiver	MMSE-IRC as baseline	
UE noise figure	9dB	
UE speed	3km/h	
Cell selection criteria	Baseline: RSRP for intra-frequency and RSRQ for inter-frequency, with cell common bias if CRE is applied.	

WiSE 系統層級模擬器 – How? (2/2)



PHY Abstraction

- 透過線路級模擬(Link Level Simulation)與實體層抽像技術(PHY Abstraction)計算錯誤率。



WiSE 系統層級模擬器 – 功能 (1/3)

功能類型	功能列表
Network Topology	Homogeneous
	Heterogeneous
Scenario	TS 36.814 calibration
	TR 36.828 eIMTA
	TR 36.872 SCE
	TR 36.897 FD-MIMO (標準制定中; 開發中)
	TR 36.889 LAA (標準制定中; 開發中)
Transmission Mode	SISO
	SU-MIMO
	MU-MIMO (開發測試中)

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WiSE 系統層級模擬器 – 功能 (2/3)

功能類型	功能列表
Channel	TU
	ETU
	SCM (開發測試中)
	3D SCM (開發測試中)
Scheduling Scheme	Round-Robin (RR)
	Proportional Fair (PF)
	FIFO
	Fixed FDM UL and RR DL
Traffic Model	Full buffer
	3GPP FTP 1
	3GPP FTP 3

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WiSE 系統層級模擬器 – 功能 (3/3)

功能類型	功能列表
Link-to-system mapping	EESM PHY abstraction RBIR PHY abstraction (開發測試中)
Output	Jain fairness index Resource utilization HARQ retransmission number per Sec. Capacity (bps) Spectral efficiency (bps/Hz) Cell edge spectral efficiency Average packet delay (Sec.)

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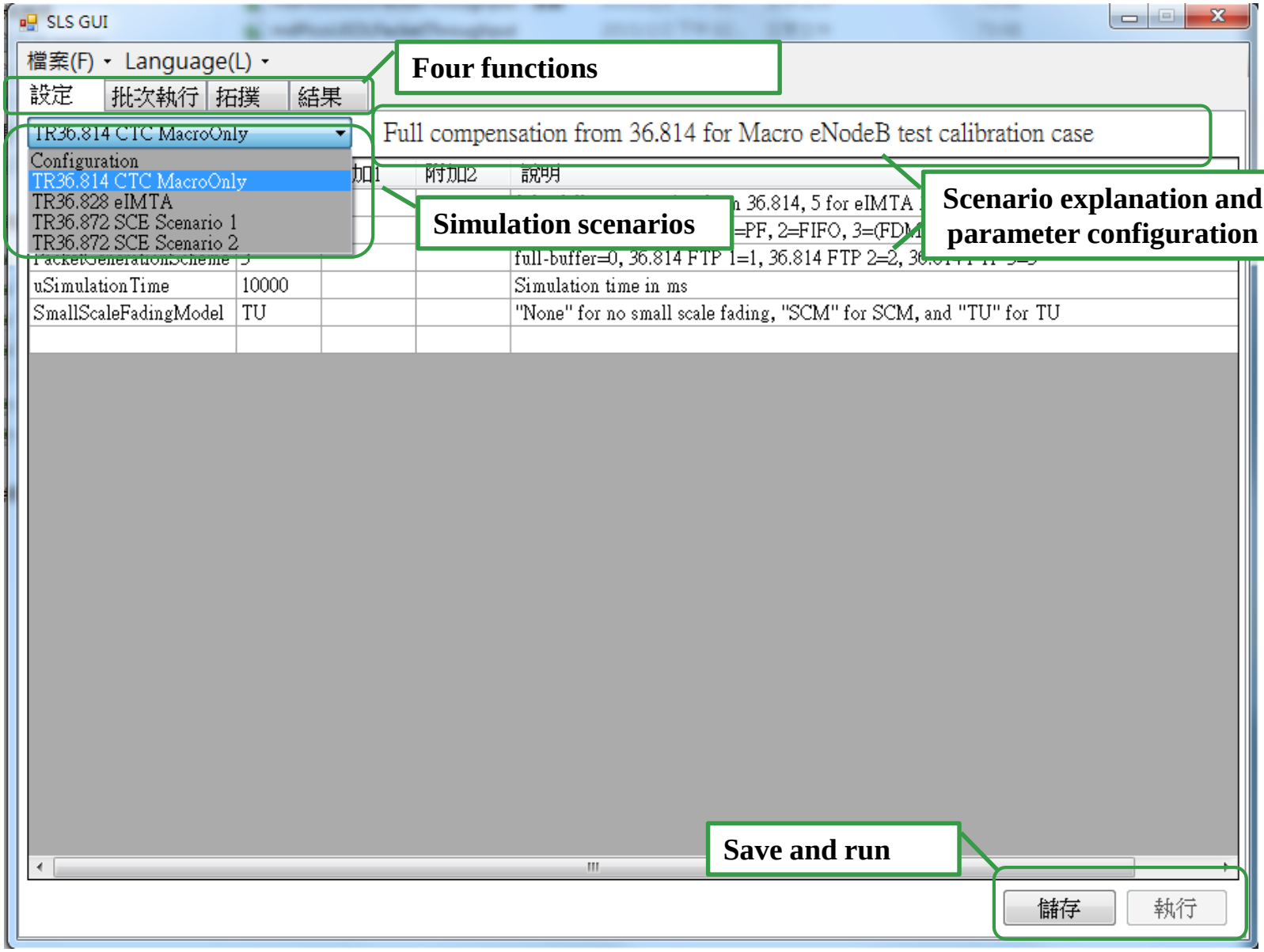
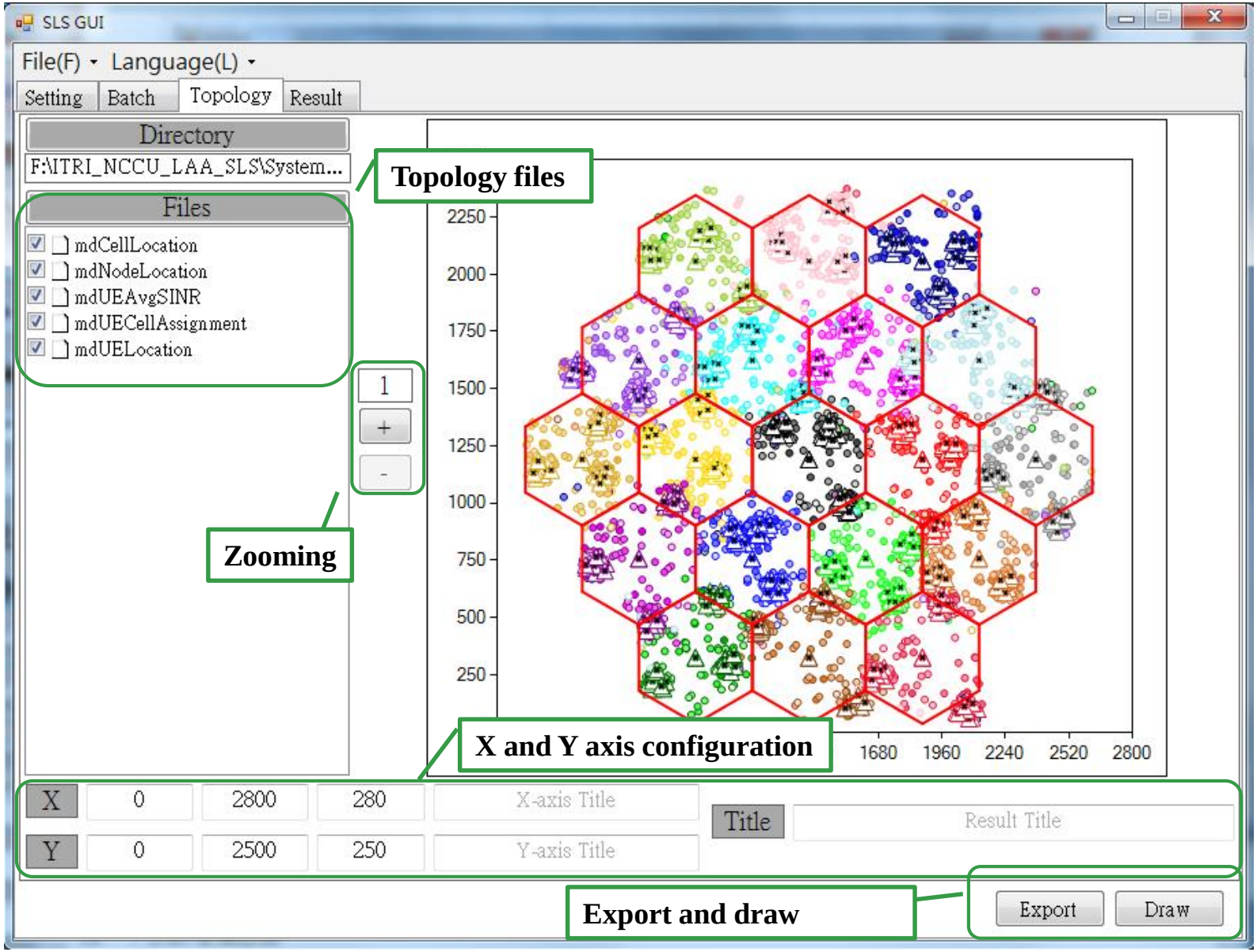
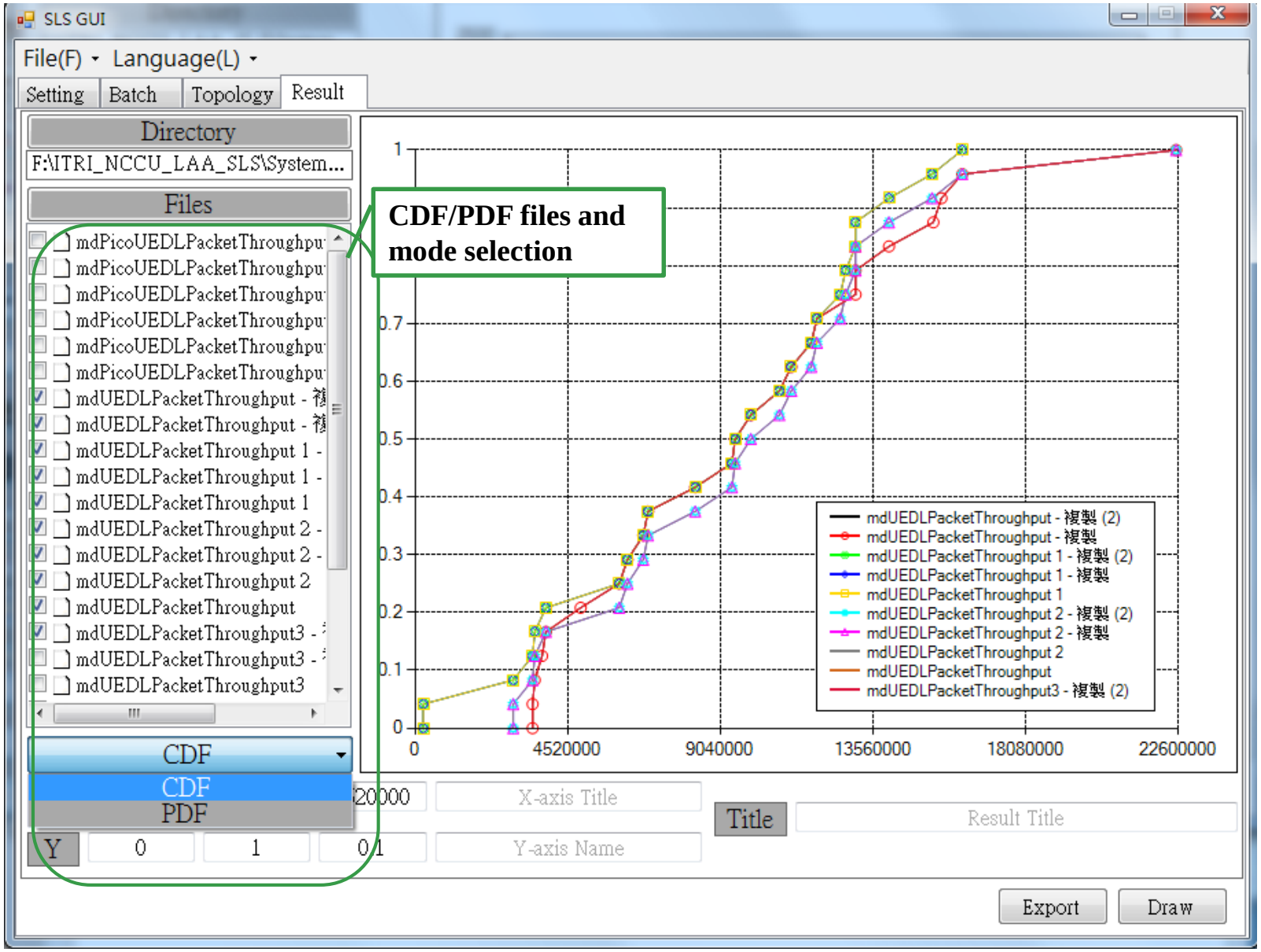
圖形化使用介面


SLS GUI
檔案(F)
Language(L)
設定
批次執行
拓撲
結果
Four functions
TR36.814 CTC MacroOnly
Configuration
TR36.814 CTC MacroOnly
TR36.828 eIMTA
TR36.872 SCE Scenario 1
TR36.872 SCE Scenario 2
Simulation scenarios
Full compensation from 36.814 for Macro eNodeB test calibration case
Scenario explanation and parameter configuration
附加1
附加2
說明
full-buffer=0, 36.814 FTP 1=1, 36.814 FTP 2=2,
uSimulationTime
10000
Simulation time in ms
SmallScaleFadingModel
TU
"None" for no small scale fading, "SCM" for SCM, and "TU" for TU
Save and run
儲存
執行

圖形化使用介面 – Topology



圖形化使用介面 – CDF/PDF



The FACT of WiSE

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Fast

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Cloud

Training

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執行速度快

- 執行速度比較
  - 以 I7+8G RAM 模擬一個 2x2 MIMO 系統運行 100 sub-frames 為例:

單位: 秒

	WiSE	V	I
不使用通道情況數據	1.173	186.2	28.6
使用通道情況數據	4.295 eTU	294.5 eTU	69.969 SCM Serving cell only

效能評估

- 功能比較

	Language	Code lines	FDD DL	FDD UL	TDD	Additional requirements	Speed
WiSE	C++	21 k	✓	✓	✓	C++ compiler	Fast
V	Matlab	15 k	✓			Matlab (限學術使用)	Slow
I	Python and C++ with an event-driven core	33 k + 50 k (core)	✓	✓		Intel MKL	Medium

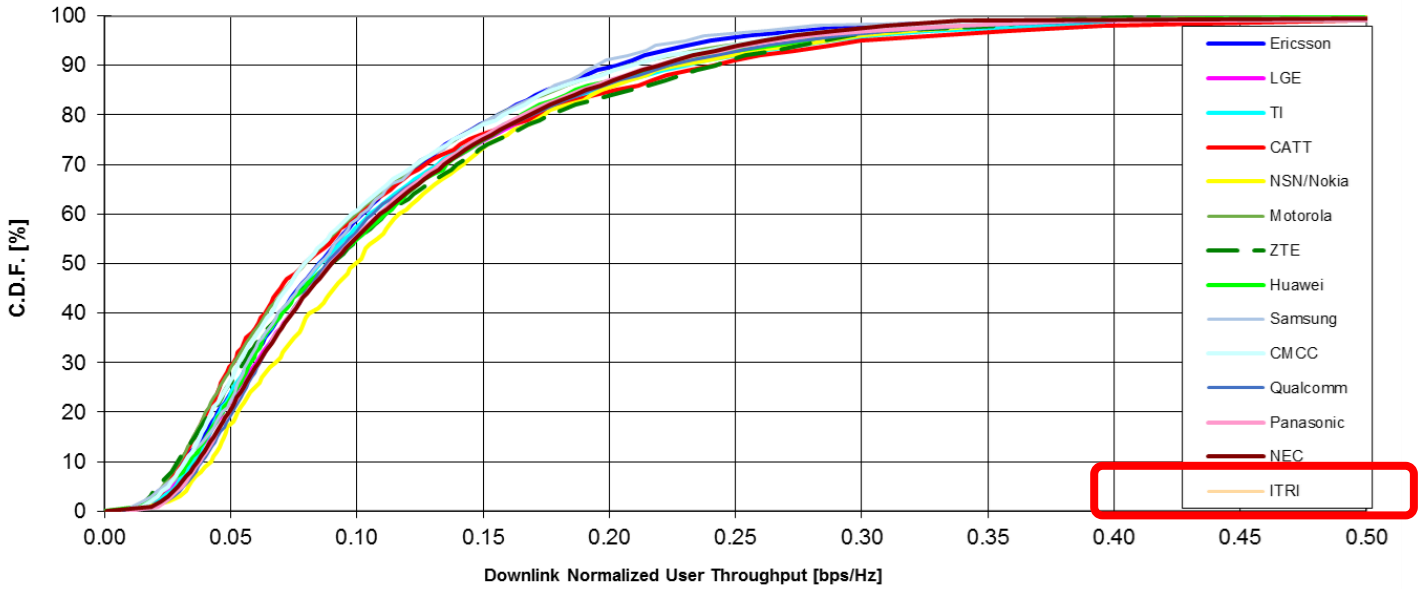
Fast

Accurate

Cloud

Training

模擬結果比對(3GPP TR 36.814)



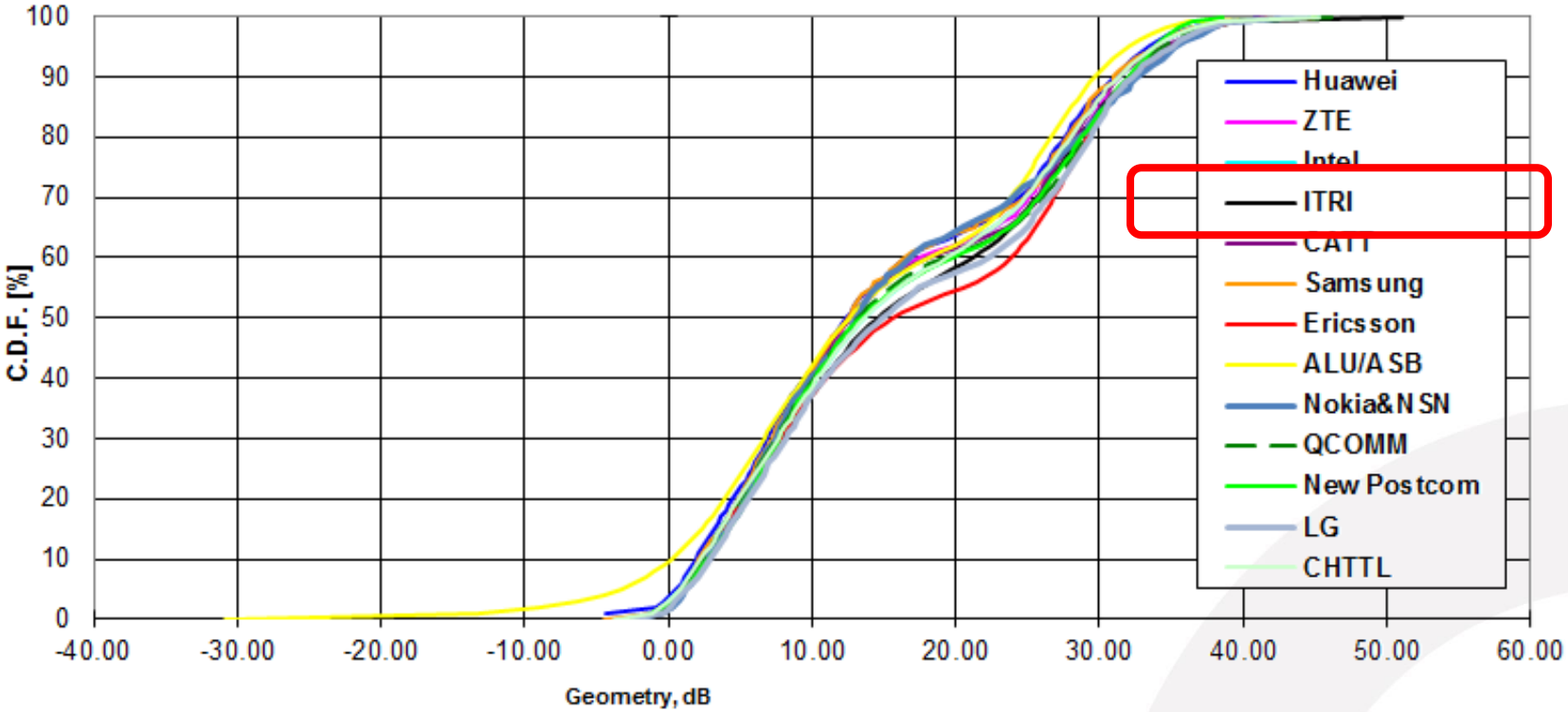
Distributions of DL normalized UE throughput under 3GPP case 1

Direction	Metric	Case 1 3D (WiSE)	Case 1 3D	Case 1 2D (WiSE)	Case 1 2D
Downlink	Cell spectral efficiency	1.482	1.5	1.05	1.1
	Cell-edge user spectral efficiency	0.038	0.035	0.026	0.026
Uplink	Cell spectral efficiency	1.01	0.99	0.82	0.74
	Cell-edge user spectral efficiency	0.031	0.036	0.026	0.031

Spectral efficiencies

模擬結果比對 (3GPP TR 36.828) – eIMTA

Geometry



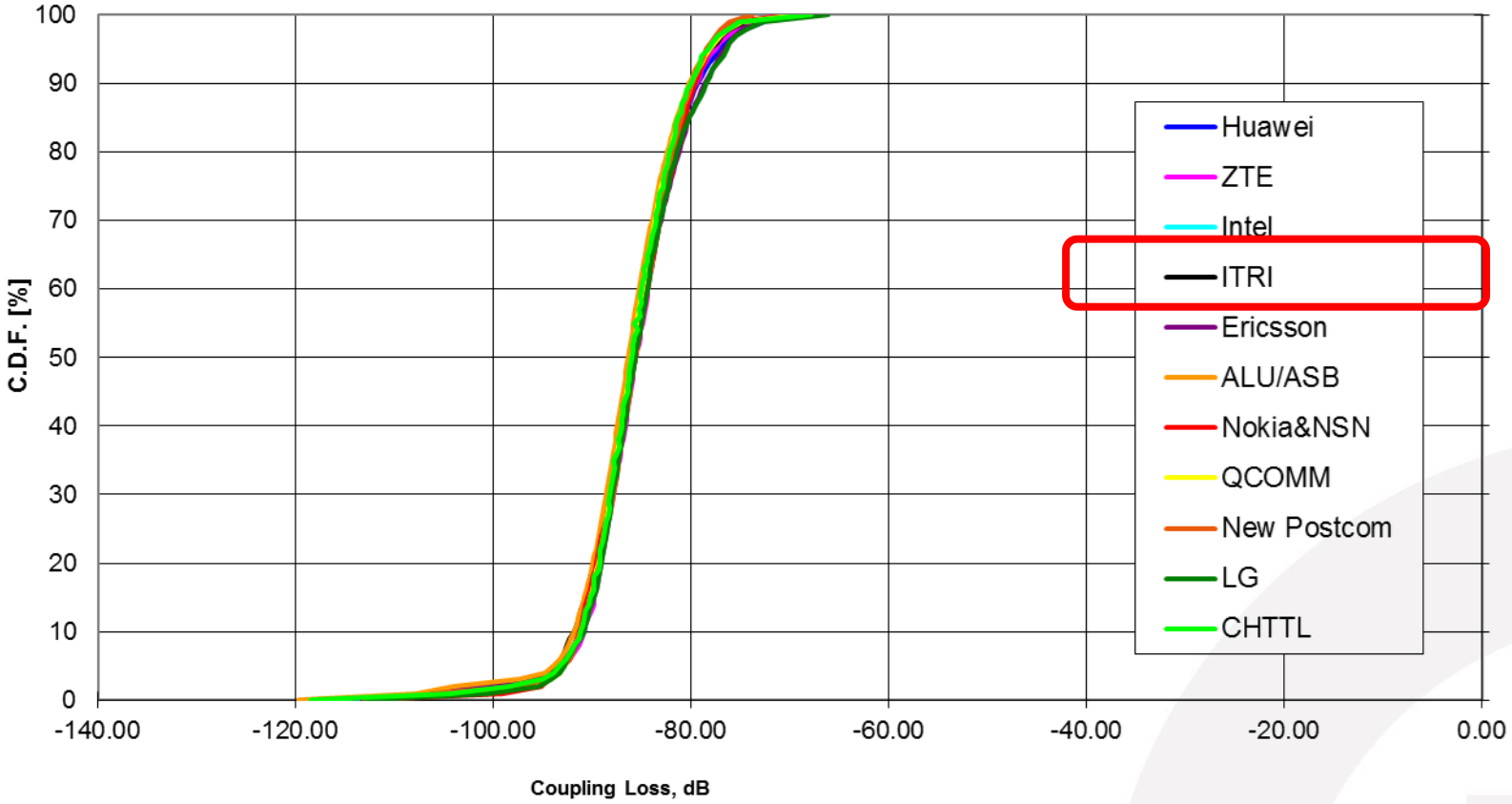
模擬結果比對 (3GPP TR 36.828) – eIMTA

Packet throughput

Source	Huawei	ZTE	Intel	ITRI	CATT	Samsung	Nokia&NSN	Qualcomm	New Postcom	LG	CHTTL
Percentile	**UE average packet throughput-UL Mbps(lambda=0.25)**										
5	12.38	10.56597	9.8	10.94	13.04	10.64	10.58	8.02	7.66	7.33	10.14
50	14.76	13.84083	12.7	12.9	14.45	14.14	13.25	15.30	13.86	14.37	12.86
95	14.87	13.92923	14	14.36	15.06	14.43	14.81	15.38	15.41	14.95	14.27
	Cell average packet throughput-UL Mbps(lambda=0.25)										
	14.37	13.18	12.2	12.84	14.28	13.74	12.98	13.96	12.81	12.90	12.79
Percentile	**UE average packet throughput-UL Mbps(lambda=1)**										
5	8.35	6.36	5.5	4.48	7.53	8.30	7.29	5.71	3.69	2.21	4.67
50	14.65	10.89	9.1	9.64	11.68	12.90	10.97	15.18	8.41	7.83	9.87
95	14.87	13.86	12.3	12.48	13.86	14.43	14.89	15.38	14.26	14.95	12.13
	Cell average packet throughput-UL Mbps(lambda=1)										
	13.07	10.60	9	9.1782	11.27	11.58	10.71	12.91	8.81	8.60	9.41
Percentile	**UE average packet throughput-DL Mbps(lambda=0.5)**										
5	15.21	15.03	15.8	17.6	18.18	14.60	13.58	13.51	14.03	10.39	14.72
50	19.9	19.73	18.8	21.02	20.95	19.10	18.68	21.18	23.04	19.60	18.79
95	20.41	20.68	20.1	22.35	21.98	20.90	20.38	21.39	23.27	21.45	21.16
	Cell average packet throughput-DL Mbps(lambda=0.5)										
	19.39	18.97	18.4	20.59	20.62	18.85	18.22	20.46	20.94	18.41	18.45
Percentile	**UE average packet throughput-DL Mbps(lambda=2)**										
5	9.03	1.96	1.52	0.7	0.82	2.04	0.95	8.32	3.37	3.43	2.47
50	19.61	12.22	11.3	9.51	11.97	12.62	9.92	21.05	9.03	12.92	9.45
95	20.36	18.74	17.07	19.11	19	18.18	20.31	21.39	23.10	21.22	20.14
	Cell average packet throughput-DL Mbps(lambda=2)										
	17.23	11.39	10.6	9.4403	10.52	11.26	9.78	18.27	10.79	13.19	9.12

模擬結果比對 (3GPP TR 36.828) – eIMTA

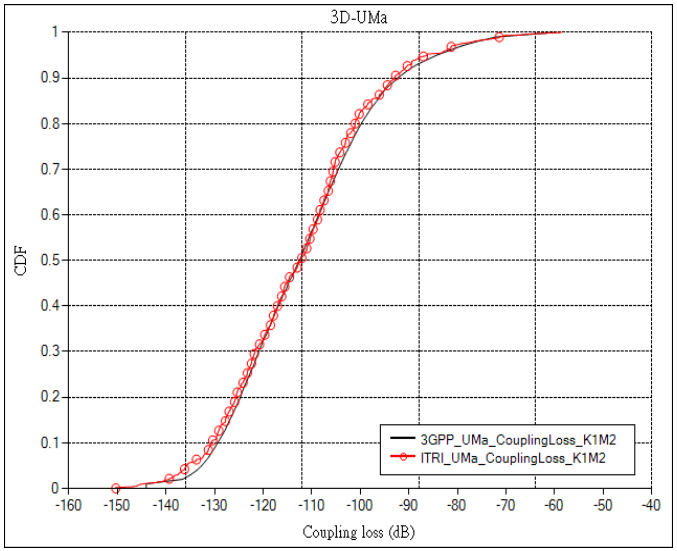
Coupling loss

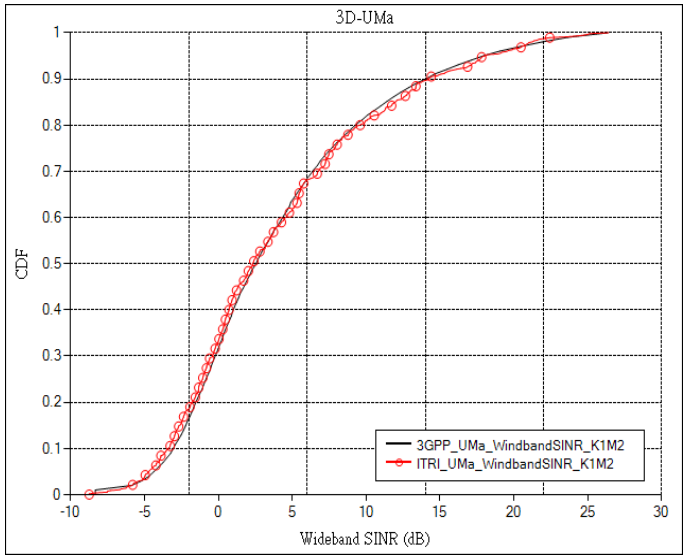


模擬結果比對 (3GPP TR 36.897) – FD-MIMO

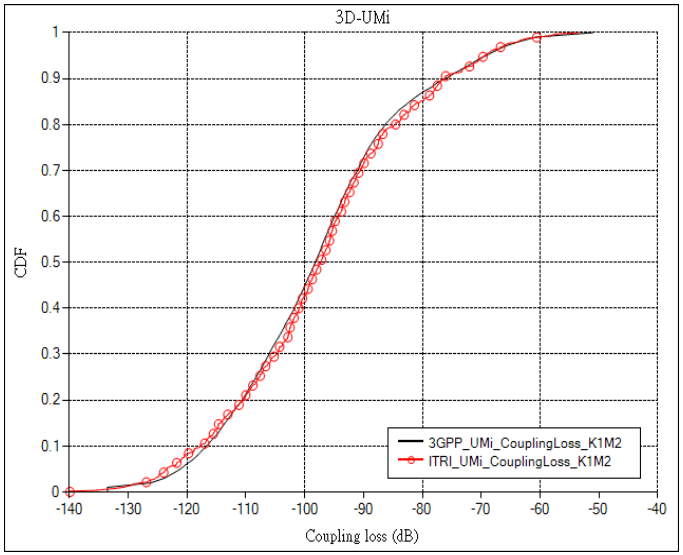
CDF of Coupling loss & Wideband SINR

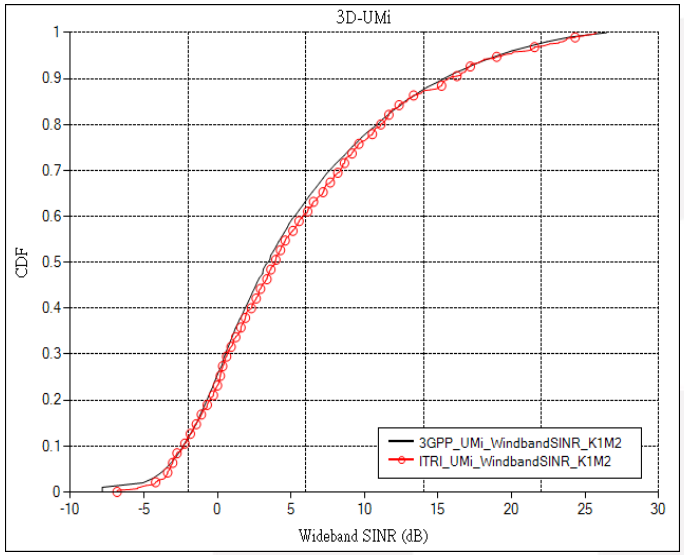
- 3D-UMa



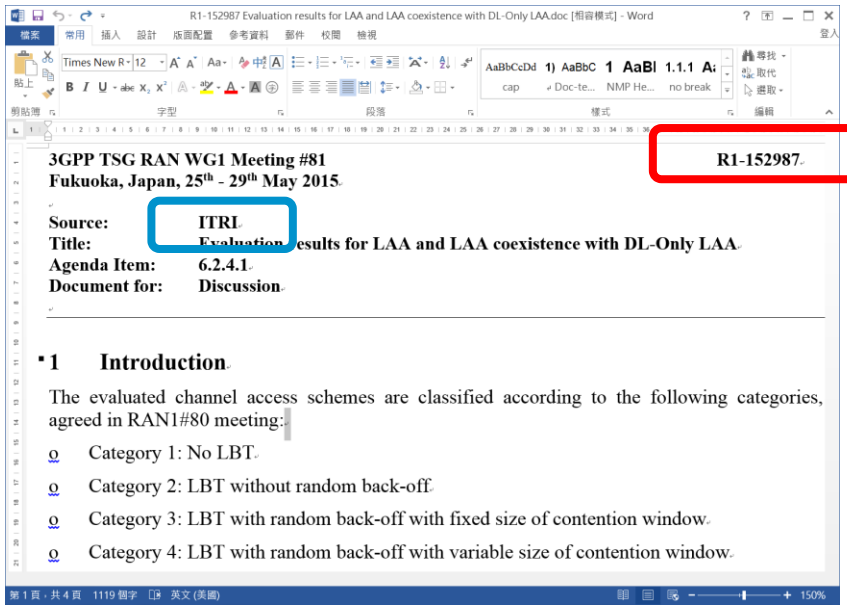


- 3D-UMi





模擬結果收錄在 3GPP TR 36.889 (LAA)



R1-152987 Evaluation results for LAA and LAA coexistence with DL-Only LAA.doc [相容模式] - Word

3GPP TSG RAN WG1 Meeting #81 R1-152987
Fukuoka, Japan, 25th - 29th May 2015

Source: ITRI
Title: Evaluation results for LAA and LAA coexistence with DL-Only LAA
Agenda Item: 6.2.4.1
Document for: Discussion

1 Introduction

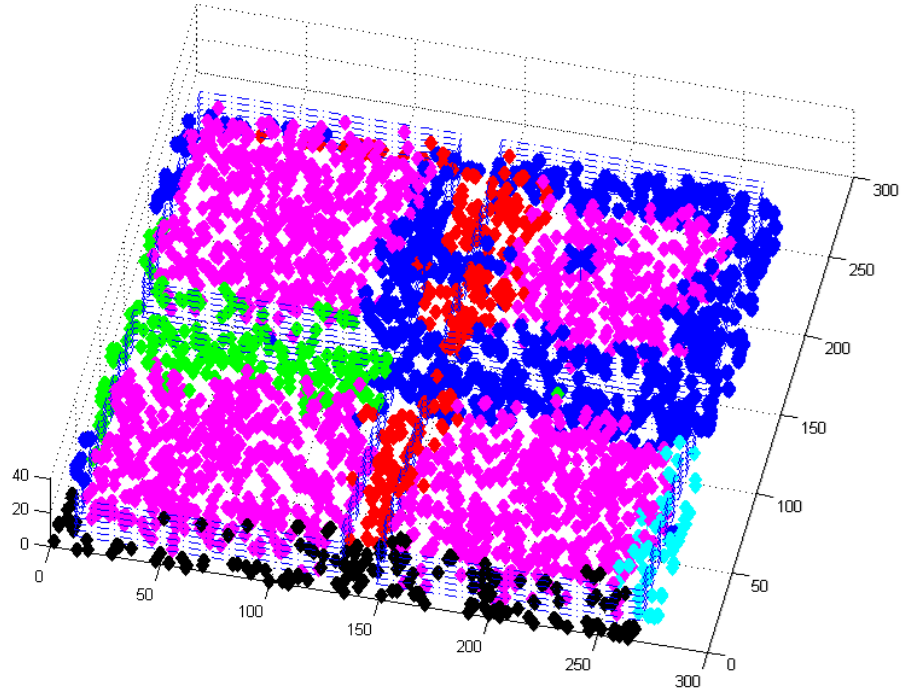
The evaluated channel access schemes are classified according to the following categories, agreed in RAN1#80 meeting:

- Category 1: No LBT
- Category 2: LBT without random back-off
- Category 3: LBT with random back-off with fixed size of contention window
- Category 4: LBT with random back-off with variable size of contention window

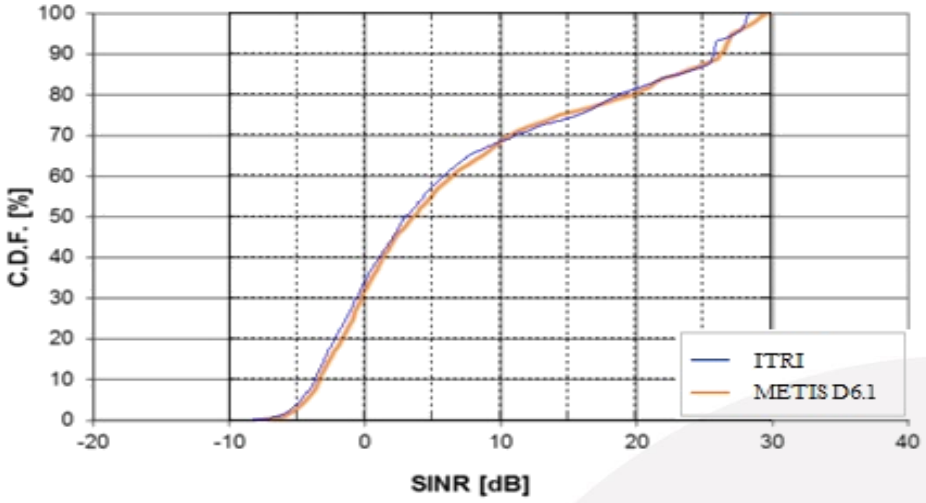
R1-152987/So	2	UPT CDF [Mbps]	5%	21.2686	18.7647	12.8914	10.8307	9.4908	7.2978
			50%	35.7498	36.6630	31.4309	30.3217	28.6130	22.8692
			95%	76.2715	77.3298	73.9907	72.4842	70.5043	58.808
			Mean	43.745	43.2593	36.2734	33.1379	28.4913	25.8865
		Delay CDF [s]	5%	0.0533	0.0527	0.05526	0.0565	0.0573	0.069
			50%	0.1146	0.1118	0.1304	0.1351	0.1432	0.1792
			95%	0.1879	0.2173	0.3141	0.3683	0.4232	0.5581
			Mean	0.1089	0.1135	0.1488	0.1684	0.2128	0.2324
		ρ		0.9531	0.9476	0.9045	0.8884	0.8715	0.8674
		BO		10.3117%	11.5763%	26.6818%	29.6909%	40.8268%	45.776%
		λ		1		2		3	
Additional information: Without licensed carrier Sensing threshold used: -82 dBm Whether defer periods are used or not: yes CCA and ECCA slot length: 20 us Inter-operator synchronization for LAA-LAA coexistence: un-synchronized Channel occupancy time : 4ms									
R1-152987/	3	UPT CDF [Mbps]	5%	20.7955	18.2161	13.1149	10.6405	7.3013	6.6978
			50%	35.6377	36.2444	31.3583	29.4203	23.144	20.5274
			95%	76.7124	78.5855	74.8886	72.5195	65.7822	57.1897
			Mean	43.7647	43.0408	36.6843	32.7631	27.2702	23.9094
		Delay CDF [s]	5%	0.053	0.0519	0.0547	0.0564	0.062	0.0717
			50%	0.1147	0.1131	0.1307	0.1393	0.1771	0.1979
			95%	0.1962	0.2232	0.3125	0.3815	0.5414	0.6118
			Mean	0.1115	0.1147	0.1482	0.1716	0.2201	0.2569
		ρ		0.9516	0.9425	0.9101	0.8845	0.8578	0.8483
		BO		10.9658%	11.6746%	25.1652%	30.0737%	47.2075%	52.0249%
		λ		1		2		3	
Additional information: Without licensed carrier Sensing threshold used: -82 dBm Whether defer periods are used or not: yes CCA and ECCA slot length: 20 us Inter-operator synchronization for LAA-LAA coexistence: un-synchronized Channel occupancy time : 4ms									

R1-152987 模擬結果被收錄在 TR36.889

5G METIS模擬數值比對 (Calibration Case 3)



Blue : Macro BS
Green : Micro BS 1
Red : Micro BS 2
Light Blue : Micro BS 3
Black : Micro BS 4
Purple : Femto BS



符合 METIS 模擬結果

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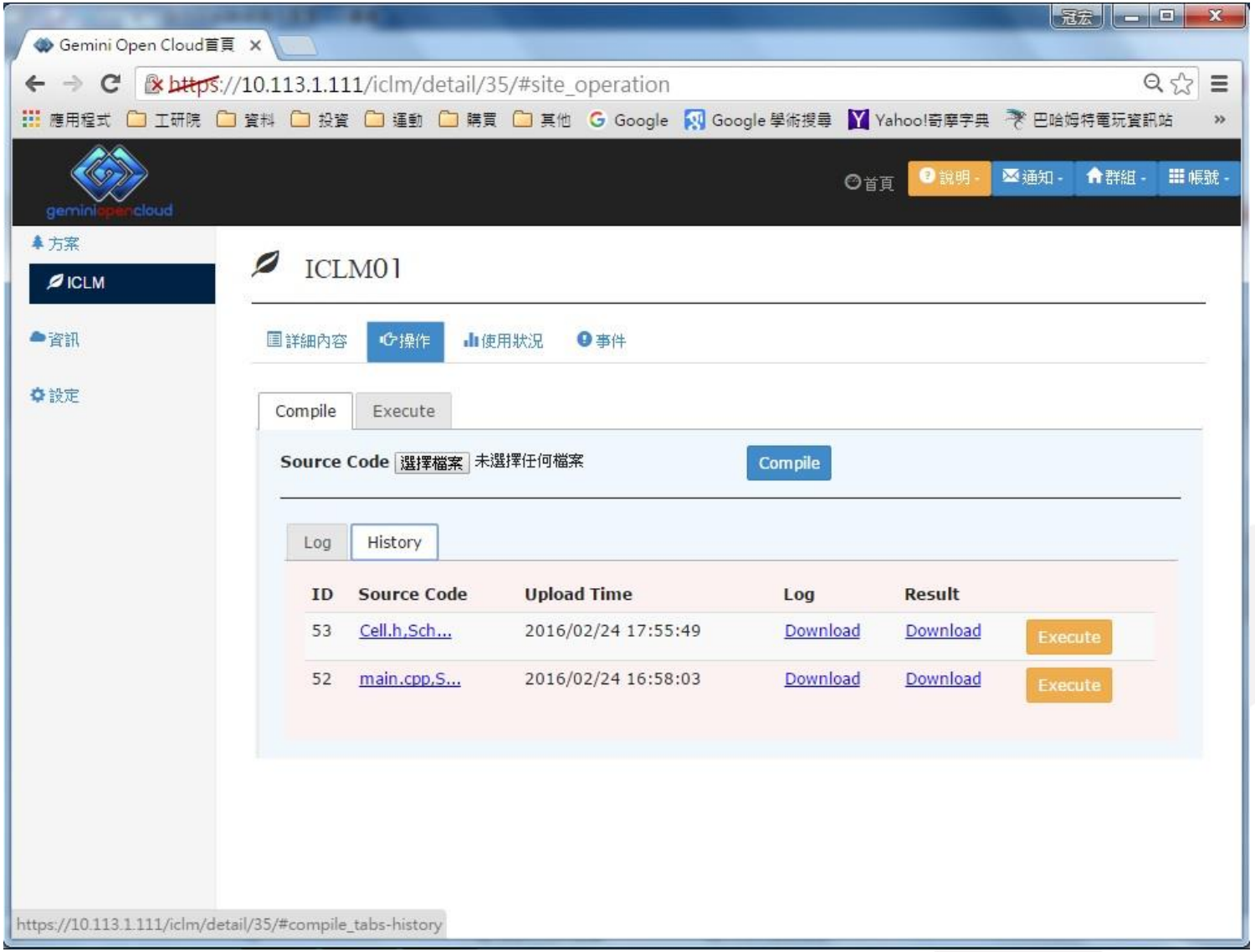
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Result
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2016/02/24 16:58:03
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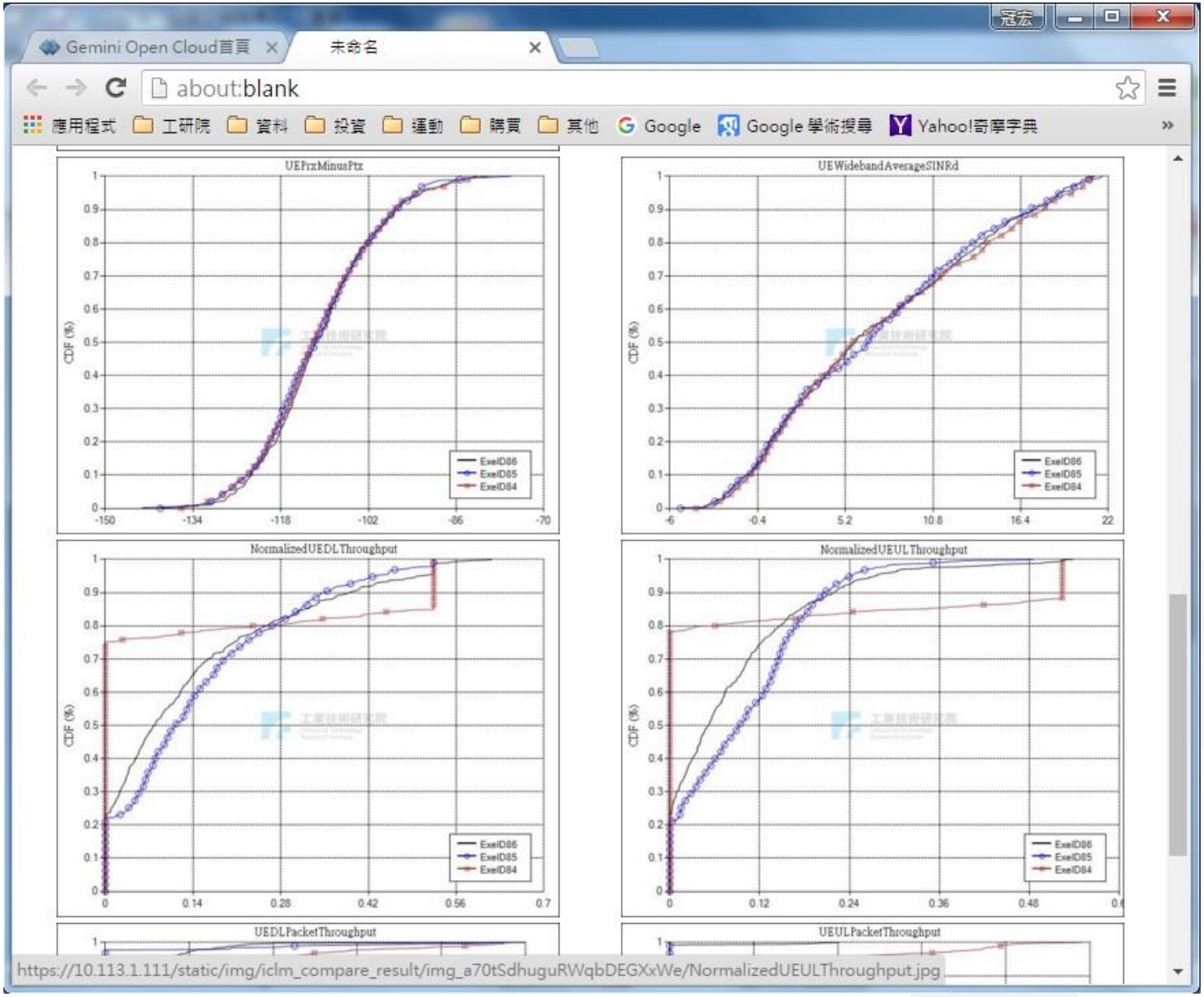
Download
Execute
https://10.113.1.111/iclm/detail/35/#compile_tabs-history

模擬結果線上瀏覽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未命名
about:blank
UEPrxMinusPtx
UEWidebandAverageSINRd
NormalizedUEDLThroughput
NormalizedUEULThroughput
UEDLPacketThroughput
UEULPacketThroughput
CDF (%)
ExeID86
ExeID85
ExeID84
https://10.113.1.111/static/img/iclm_compare_result/img_a70tSdhuguRWqbDEGXxWe/NormalizedUEULThroughput.jpg

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詳盡的說明文件

- Library Reference Web

Microsoft Word
Document

- List of Features

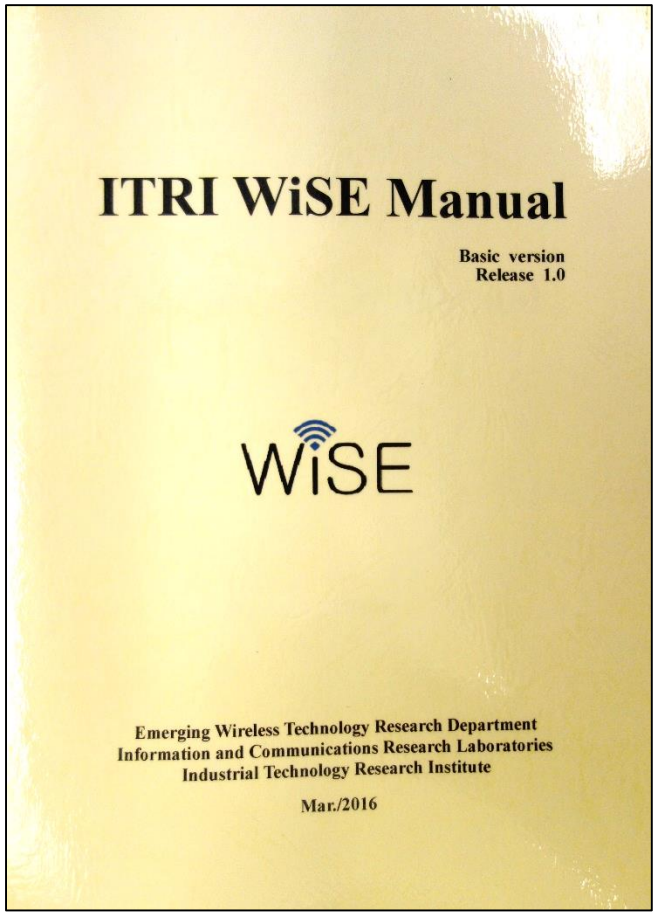
Microsoft Word
7 - 2003 Docume

- Simulation Parameters

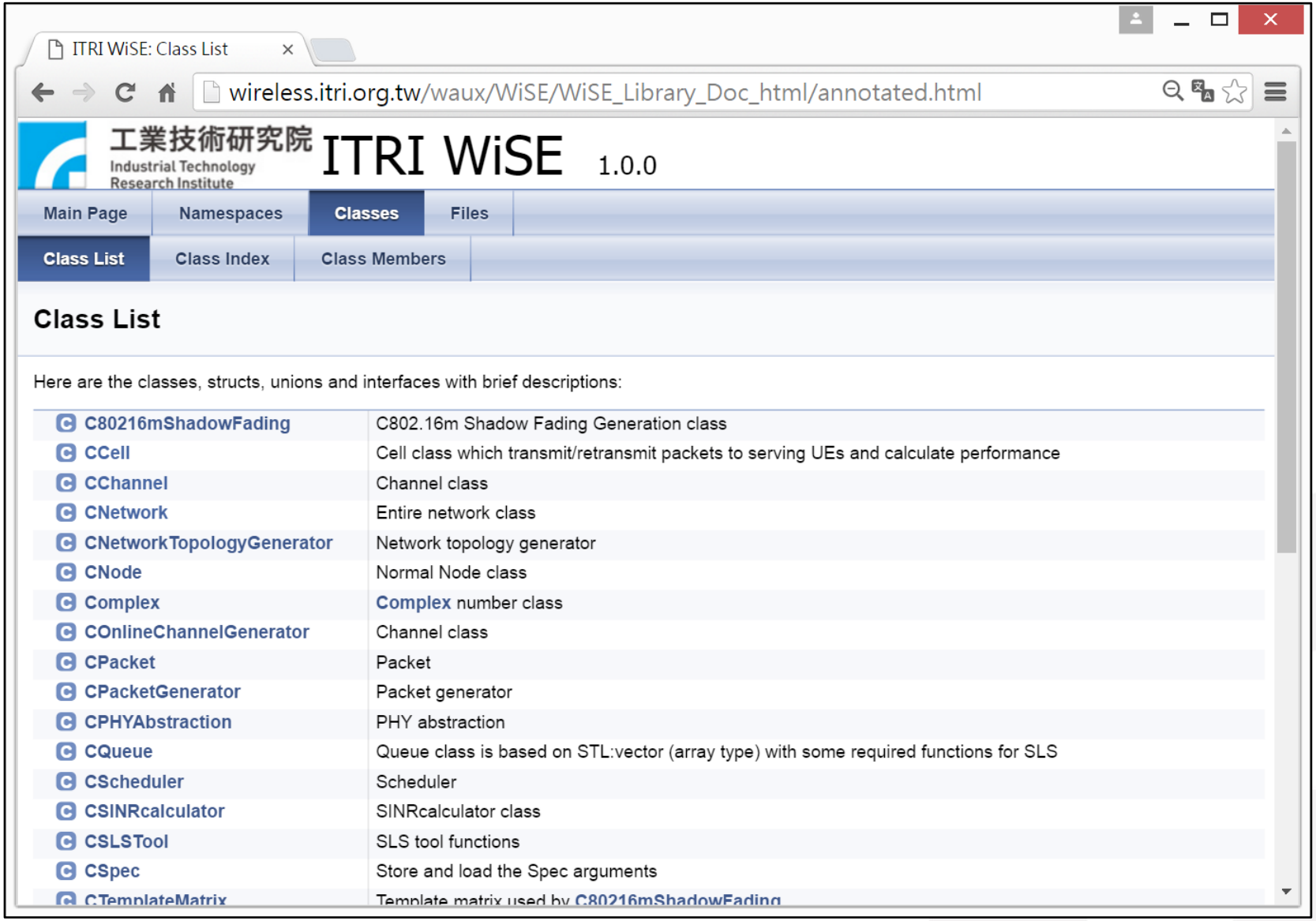
Microsoft Word
7 - 2003 Docume

- Calibration Guide

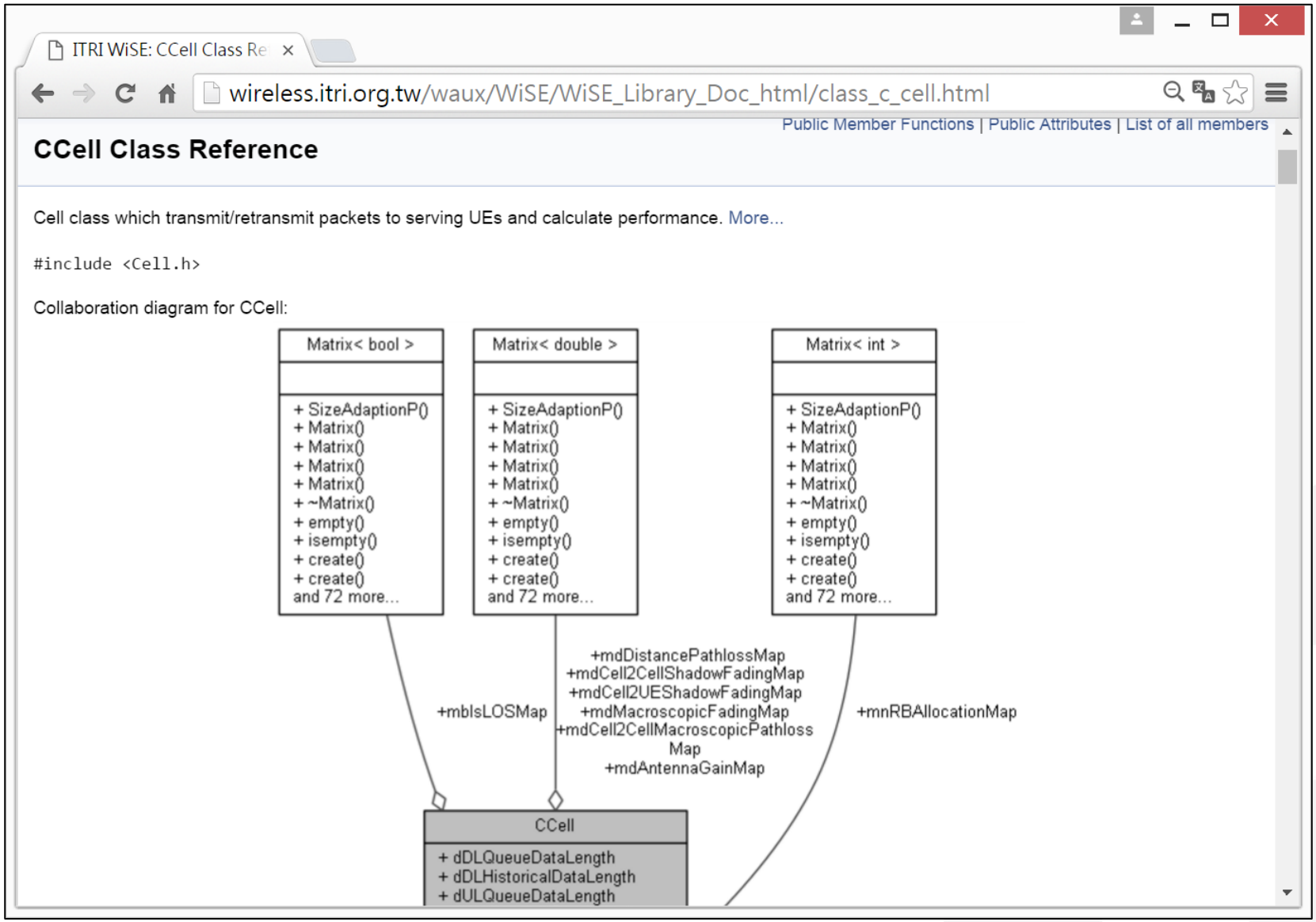
Microsoft Word
7 - 2003 Docume



線上函式庫查詢


ITRI WiSE: Class List
wireless.itri.org.tw/waux/WiSE/WiSE_Library_Doc_html/annotated.html
工業技術研究院
Industrial Technology Research Institute
ITRI WiSE 1.0.0
Main Page
Namespaces
Classes
Files
Class List
Class Index
Class Members
Class List
Here are the classes, structs, unions and interfaces with brief descriptions:
C80216mShadowFading C802.16m Shadow Fading Generation class
CCell Cell class which transmit/retransmit packets to serving UEs and calculate performance
CChannel Channel class
CNetwork Entire network class
CNetworkTopologyGenerator Network topology generator
CNode Normal Node class
Complex Complex number class
COnlineChannelGenerator Channel class
CPacket Packet
CPacketGenerator Packet generator
CPHYAbstraction PHY abstraction
CQueue Queue class is based on STL:vector (array type) with some required functions for SLS
CScheduler Scheduler
CSINRcalculator SINRcalculator class
CSLSTool SLS tool functions
CSpec Store and load the Spec arguments
CTemplateMatrix Template matrix used by C80216mShadowFading

線上函式庫查詢– CCell Class



實體與線上訓練課程

台灣資通產業標準協會 TA
www.taics.org.tw/index.php/events/show/id/e444c211381c1034a9b5343980d8bc23
台灣資通產業標準協會
Taiwan Association of Information and Communication Standards
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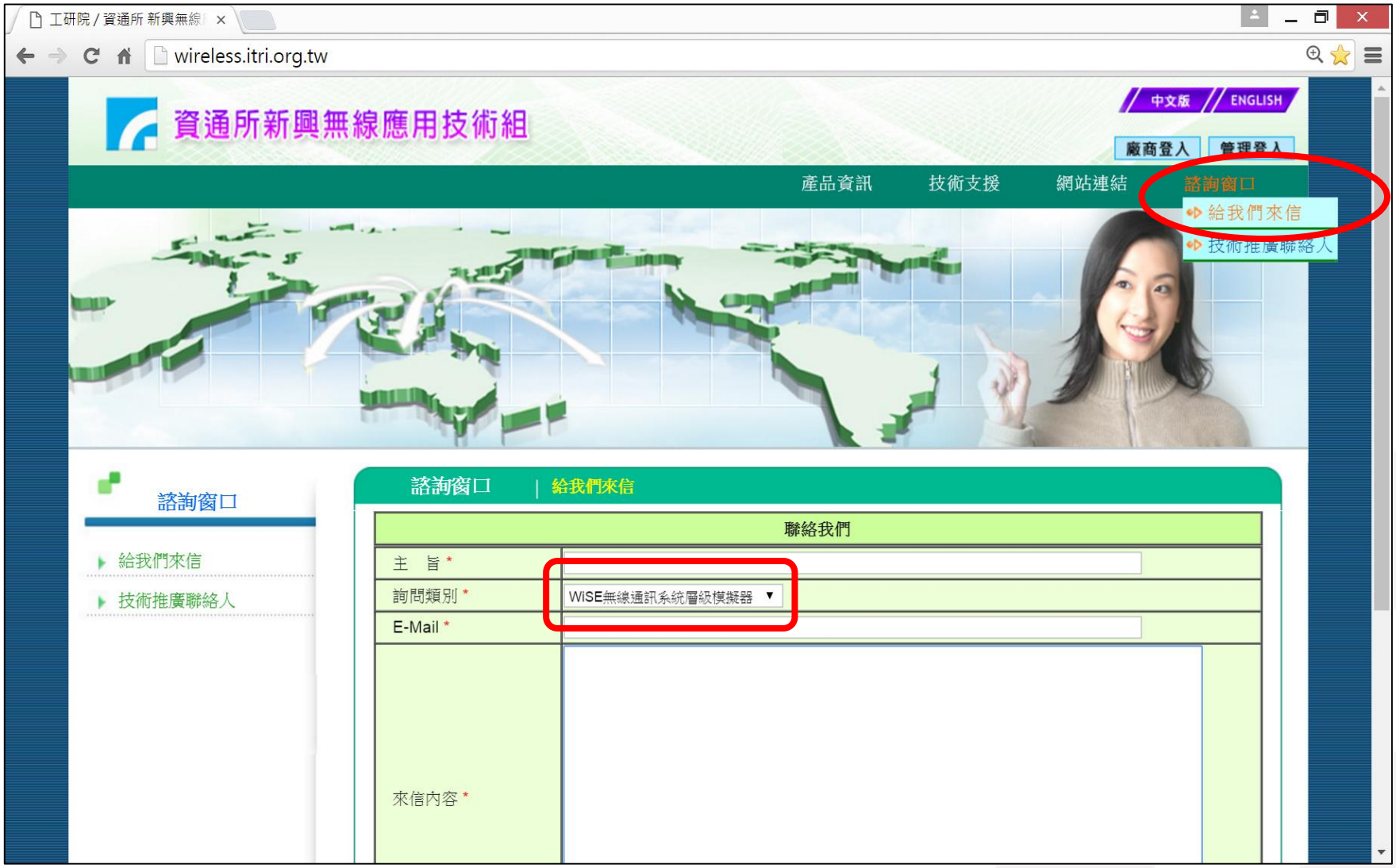
首頁 › 新訊與活動 › 活動資訊
新訊與活動
› 產業新訊
› 活動資訊
› 協會公告
活動資訊
4G/5G系統層級模擬器說明會
發佈日期：2016-03-10 | 資料來源：台灣資通產業標準協會 TAICS
活動日期 105年3月 28日（星期一）9:30am~11:30am
活動地點 永豐餘大樓TAICS台北辦公室第一會議室 (台北市重慶南路二段51號8樓之1)
主辦單位 工業技術研究院
聯絡窗口 鄭雅坪小姐；Email: yaping@itri.org.tw
報名人數 50
報名起迄 2016-03-11 ~ 2016-03-25
活動費用 免費
報名狀態 已額滿

技術問題回報 http://wireless.itri.org.tw/



總結

Curriculum Vitae

Barack Obama 2nd

President of the United States of America

Washington D.C. Metro Area | Government Administration

Current	• **President** at **United States of America**
Past	• US Senator at US Senate (IL-D) • State Senator at Illinois State Senate • Senior Lecturer in Law at University of (School
Education	• Harvard University • Columbia University in the City of New • Occidental College
Skills	C++, Matlab, WiSE

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