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5G IP Landscape Analysis

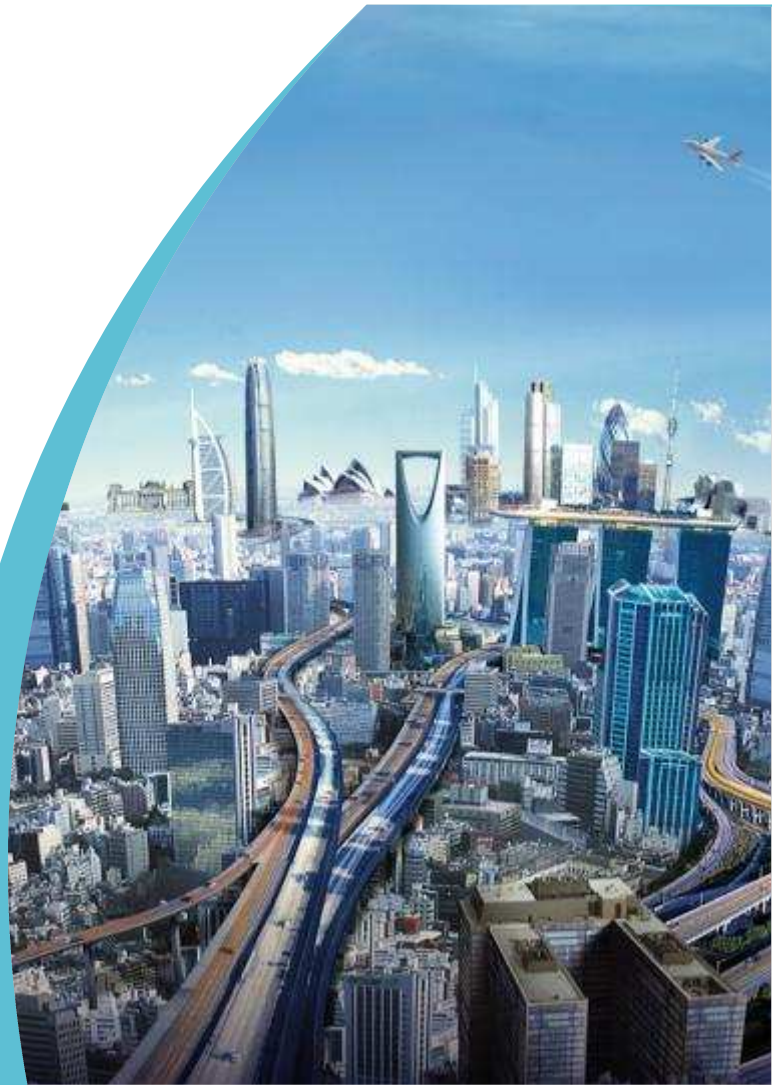
Focus on technology trends

IP KPI PROPOSAL

JULY 2018

5G PPP

The 5G Infrastructure Public Private Partnership



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Introduction

- The study represents a contribution to the definition of IP KPIs for the 5G PPP
- It aims at determining early trends for 5G mobile network underlying technologies
- We analyzed how stakeholders are gearing up towards the next 5th generation of mobile network through the angle of patent filed since 10 years (from 2007 to 2016)
- It is based only on public information, all figures and analysis have been developed using FAMPAT public databases and also publications from several bodies (IEEE, ETSI, EC,…)

Agenda

Part. 1 General Trends

- Background
- 5G “smart techno.” Characterization
- Patent Search Methodology
- Global Trends
- Where is the R&D ?
- Technology Segments Evolution

Part. 2 Top 20 Assignee Analysis

- Patent Family “Strength” Global view
- Geographical coverage by Top Assignees
- On which Segment Top assignees are investing ?
- On which Sub-segments“ Top assignees are investing ?
  - RADIO Front End
  - Modulation & WF
  - Adaptive Networking

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Background

5G is not yet fully defined in term of underlying technologies & standardization

- There is a technology continuum with LTE, LTE-A "feeding" new 5G techno. trends

Some figures regarding IPRs on LTE/LTE-A

- About 20000 patent families published since 2007
- o/w ~30% have been declared as ***"essential patents"*** (ETSI) by large players such as Qualcomm(11% of their Patents) , Samsung(10%), Huawei(10%), Nokia, Interdigital, Ericson, ZTE, LG, …
- The list of standard-essential IP for LTE/LTE-A continues to evolve as companies continue to declare patents and as the 4G standards continue to evolve.
- It is clear that the standard-essential IP for 4G is not concentrated with a few players as it was in 2G/3G, it will be the same for 5G

As a starting point, we chose to adopt 5G subfields definition from 3GPP/ETSI/5GPPP/ and other IEEE studies around 3 main segments

- Radio Access Network, Front End
- Modulation, WaveForm & Signal Processing
- Adaptive Networking Technologies

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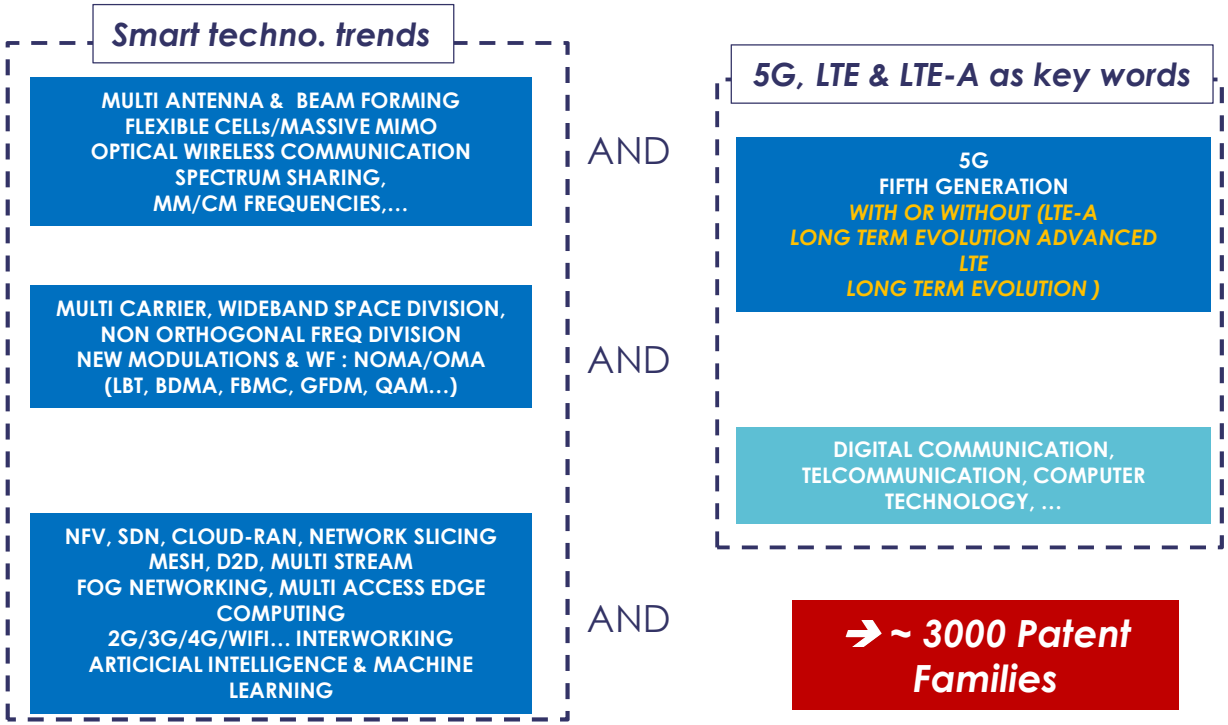
How 5G “smart” technology trends are characterized ?

5G subfields definition from ETSI/5GPPP/ and other IEEE studies

- **Radio Access Network / Front End**
- **Modulation / WaveForm / Signal Processing**
- **Adaptive Networking Technologies**



Note : The selected segments are not exhaustive. Other technics related to Optical Networks/Satellite and Future and Emerging technologies were not taken into consideration at this stage of our study

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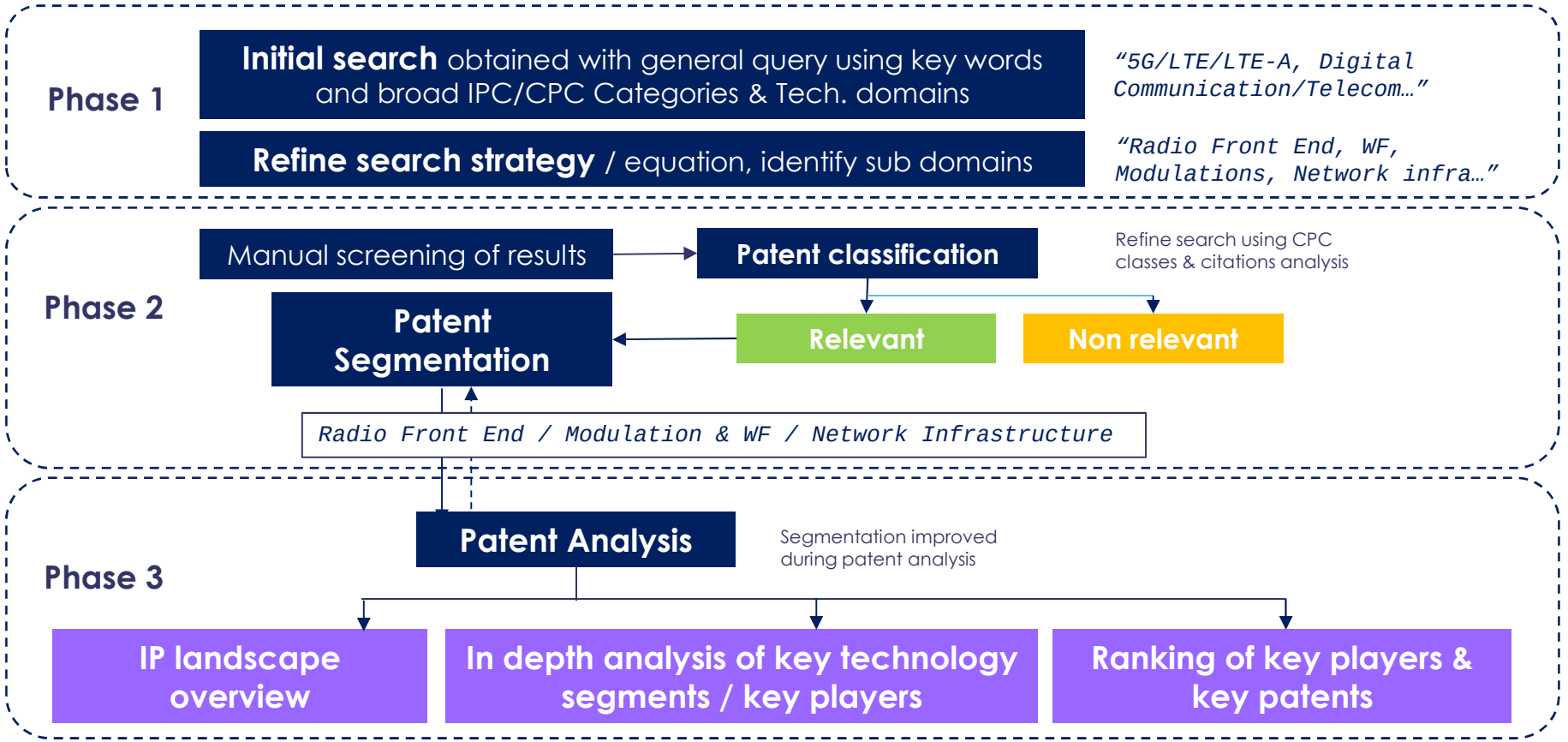
Patent Search methodology



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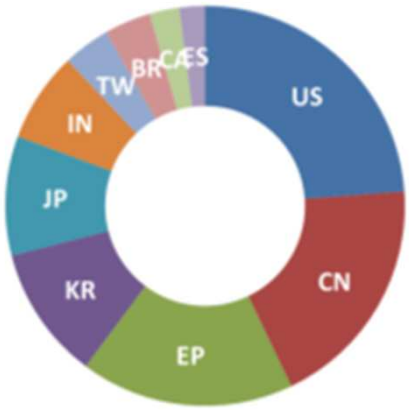
General Trends (Scope : LTE/LTE-A/5G)

Global Portfolio

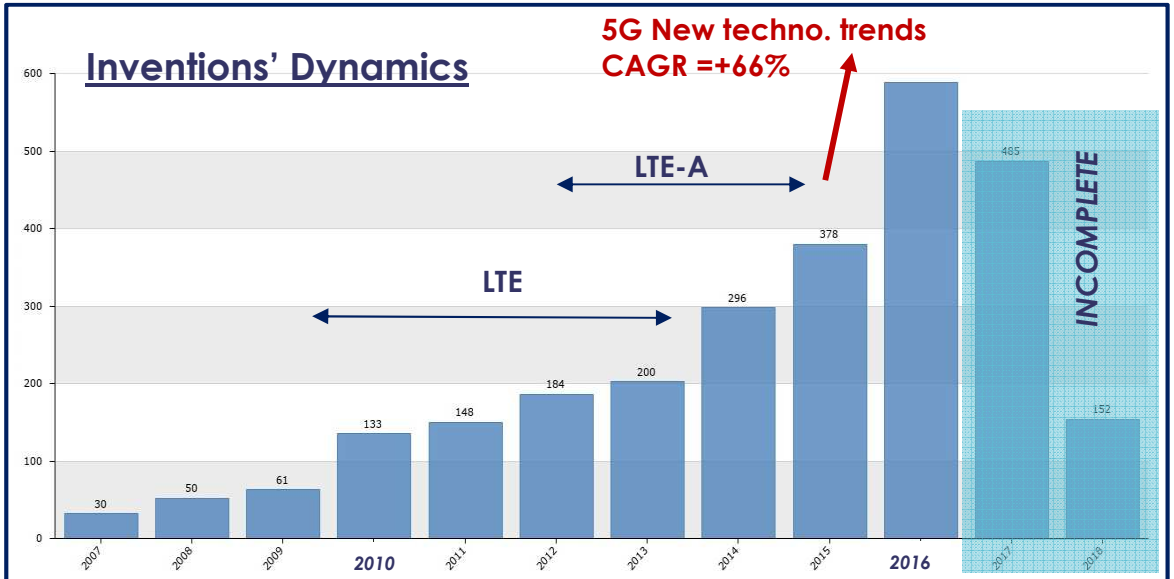
3074 patent families → **o/w 2748 in force patents**

Country of Publications

US, China and Europe Leaderships



Inventions' Dynamics



- A steep growth occurs from 2014 to 2016 related to "smart techno" trends (CGAR=+66%) ➔ future 5G standardization candidacies
- We tried to position the different periods starting from LTE to LTE-A & beyond (5G) on the figure

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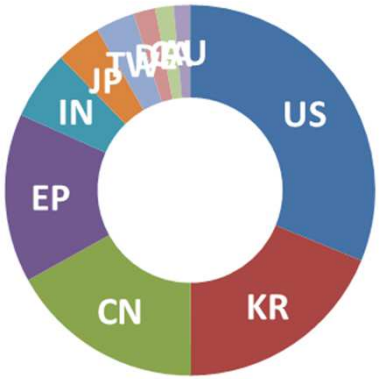
General Trends (Focus 5G only)

Global Portfolio

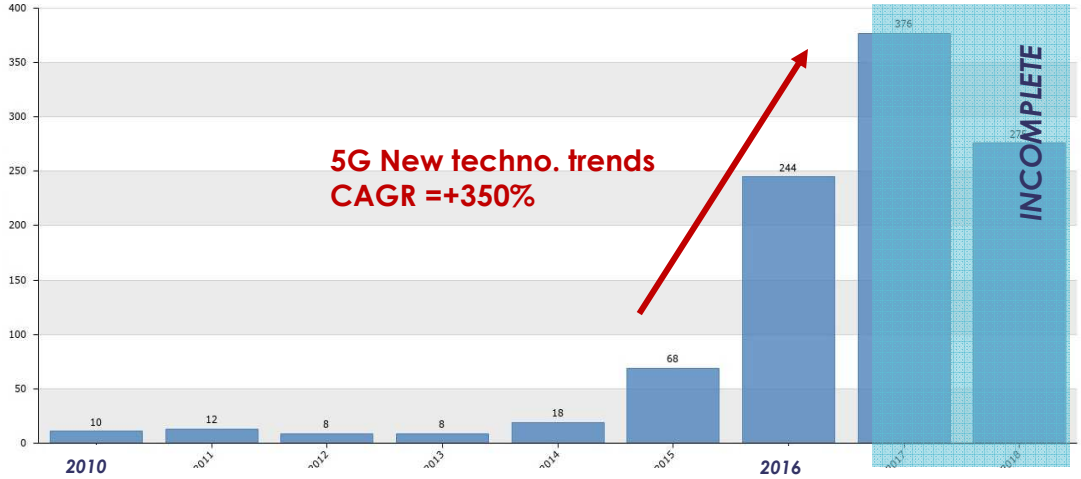
1162 patent families → o/w 1141 in force patents

Country of Publications

US, KR, China and Europe Lead



Inventions' Dynamics



- A steep growth occurs from 2015 to 2016 & beyond ➔ this is the beginning of the upcoming 5G patent wave
- This is definitely a **young and dynamic technological domain**

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Where is the R&D ? - (Scope : LTE/LTE-A/5G)

Macro Analysis

- The geographical coverage map tends to highlight targeted markets
- Usually, applicants applies patents in the country where they will sell products

- **IP protection strategy is mainly concentrated in 3 areas : US, KR/China** patents represent the big part of the selection.
- In Europe, instead of being based in national fillings, the protection is based on European applications
- **European procedures are following just after China**, showing that Europe is not late on preparing 5G
- There is similar quantity of US patents and all PCTs demonstrating the weight of US

Country of first publication

PCT (2541) – **US (2147**) – **CN (1663)** – **EP (1617**) – **KR (947)** – JP (921) – BR (355) – CA (263)

Notes

- *PCT (international procedure shared by 152 countries), EP (European Procedure)*
- **Removal of non-extended Chinese patents/utility models**

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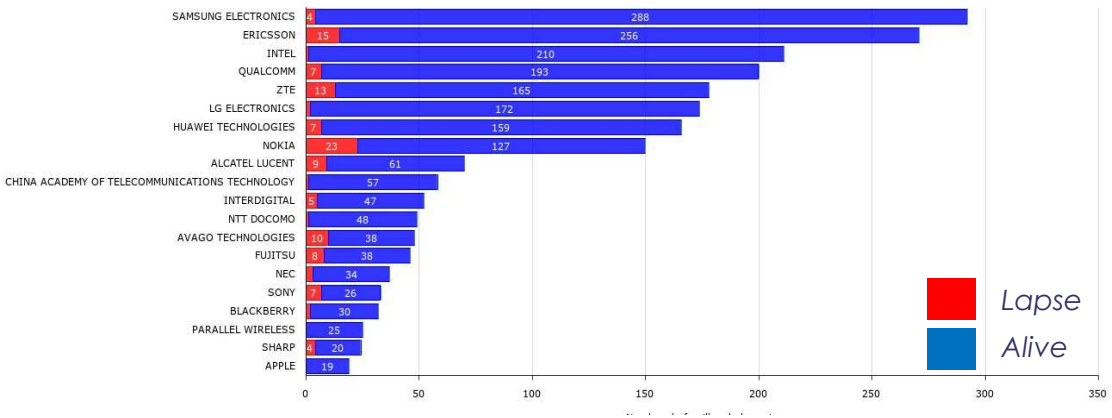
Top 20 Assignees (Scope : LTE/LTE-A/5G)

Macro Analysis

- Most of the top assignees filed patents since 2010, a pivotal year for the 3 technology segment trends
- **Samsung, Ericsson, Intel & Qualcomm** considered as "**pioneers**" for this recent technology development
- **Huawei and ZTE** are considered as serious **challengers** and will certainly enter the TOP 4 in the next coming years
- Presence of **InterDigital**, a patent license company

- Well known big players are dominant and concentrate most of the R&D capacity

- *Note that AvagoTech acquired Broadcom in 2015*



Looking at the "citations" brings a different view of TOP player ranking

1. INTEL with 5807 citations
2. QUALCOMM with 2312
3. ERICSSON with 1480
4. LG with 876
5. HUWAEI with 676
6. ZTE with 646
7. NOKIA with 627
8. SAMSUNG with 574

Cf next slide for key player respective positioning

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Geographical coverage by Top Assignees (Scope : LTE/LTE-A/5G)

Focused strategy → SAMSUNG ELECTRONICS

Wide Extension strategy → ERICSSON, INTEL, QUALCOMM

Huge presence in China → LG ELECTRONICS, ZTE, HUAWEI TECHNOLOGIES

	US	CN	EP	KR	JP	IN	TW	BR	CA	ES	RU	MX	AU	HK				
SAMSUNG ELECTRONICS	193	90	61	202	14	54		1	7	2	6	3	8		10		2	
ERICSSON	189	100	169	20	46	83	7	23	14	24	19	28	13	5		1	8	5	6
INTEL	134	130	117	65	69	51	57	46	19	27	21	16	20	39	6	18		2	4
QUALCOMM	192	153	150	139	134	143	59	94	31	11	17	18	21	8			16	14	7
LG ELECTRONICS	148	80	84	70	49	13	1	2	6	4	5	5	1		3		12		
ZTE	60	161	63	20	33	13		14	3								1	1	
HUAWEI TECHNOLOGIES	83	131	81	15	24	21		15	3								5		1
NOKIA	101	75	100	23	22	20	5	5	3	4	8	6	3	4	2	3	6	2	1
ALCATEL LUCENT	36	49	34	25	25	11	16	9	1	5	2	3	3		1			3	
CHINA ACADEMY OF TELECOMMUNICATIONS TECHNOLOGY	21	57	21	11	10	1	10					1							
NTT DOCOMO	39	41	31	13	44	13	1	10	7	4	8	8	4				1	2	1
INTERDIGITAL	39	37	37	33	30	16	33	15	16	6	12	13	18	9		5	1	16	6
AVAGO TECHNOLOGIES	38	14	7	1			2												
FUJITSU	35	24	28	17	28	3	1												
NEC	30	16	28	9	29	12													
BLACKBERRY	30	23	29	14	4	9	9												
SONY	21	23	23	7	15	10	3	5	3	3	2	1	4		4	1	3		
PARALLEL WIRELESS	25	1	3			1			1										
SHARP	20	13	11	4	15	4	3	3	2		2		2						
APPLE	18	14	8	8	10	7	8	4	1	1	1	2	3			4			

Top publication countries → US, CN, EP, KR, JP, IN

TOP 7 Assignees are leading first publication effort

PCT & EP publications are not yet present in nominate countries due to procedure timing
➔ Huge opportunity to develop strategic positions

Publication countries

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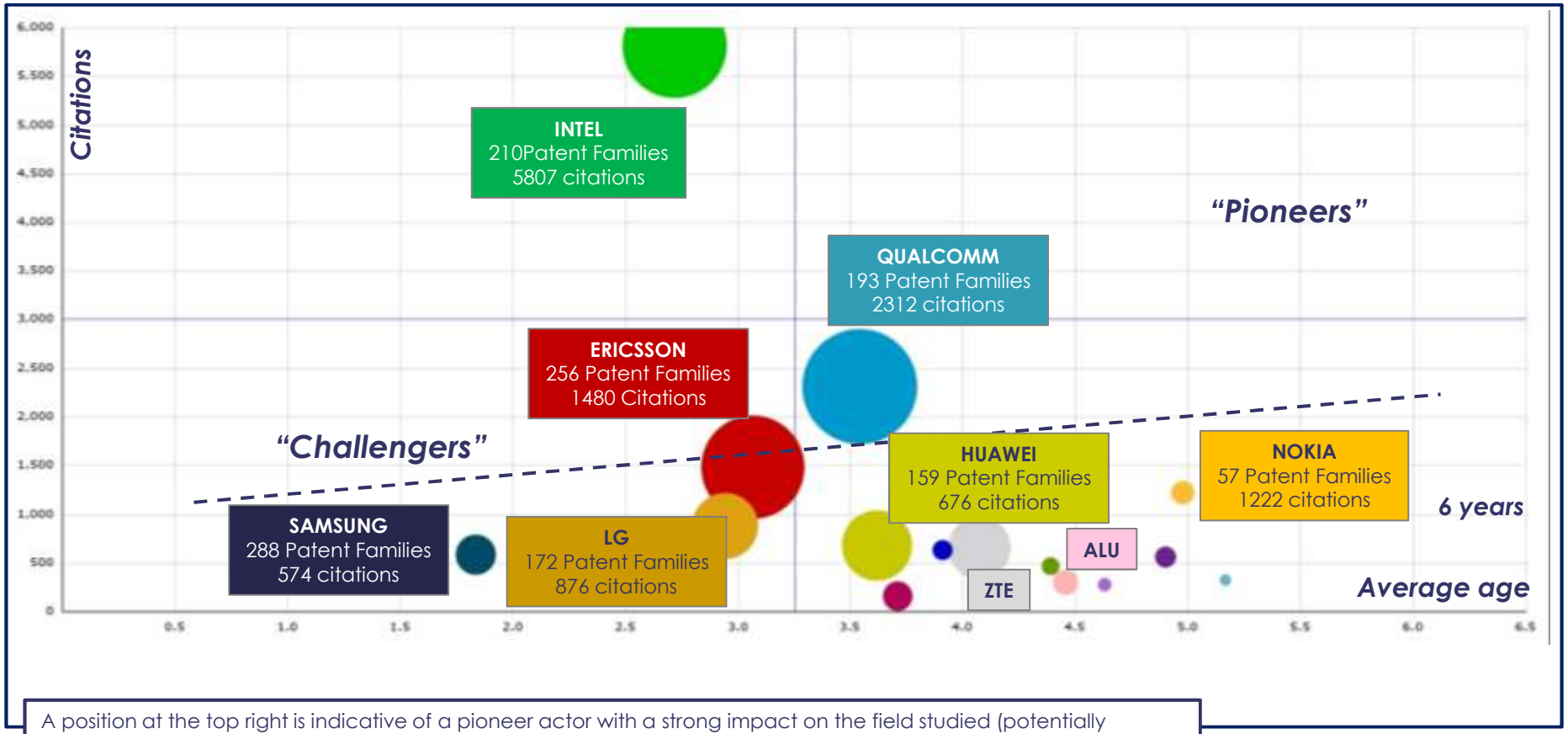
Patent Family "Strength" Global view (Scope : LTE/LTE-A/5G)



A position at the top right is indicative of a pioneer actor with a strong impact on the field studied (potentially blocking actor). The portfolios on the left side of this chart are the portfolios of the entrants. A position at the top left corresponds to a recent actor who quickly became important in the field (strong impact)

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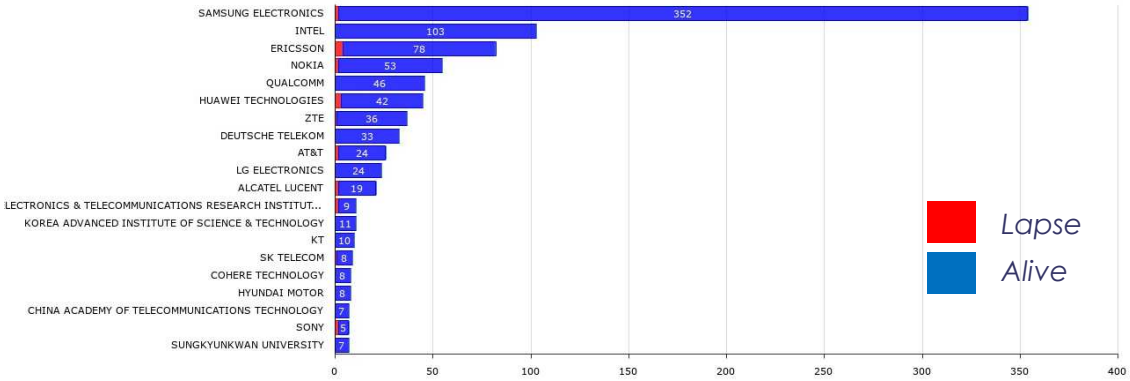
Top 20 Assignees (Focus 5G only)

Macro Analysis

- Most of the top assignees filed patents since 2015, a pivotal year for the 3 technology segments
- **Samsung, Intel, Ericsson & Qualcomm** considered as "**pioneers**" for this recent technology development
- **Huawei and ZTE** are considered as serious **challengers**
- **InterDigital,** a patent license company, not yet in the Top 20

- **Samsung big player is dominant** and concentrate most of patent families. **Ranked #1 in volume and also in citations !**



Looking at the "citations" brings a different view of TOP player ranking

1. SAMSUNG with 389 citations
2. **HUWAEI with 314**
3. QUALCOMM with 169
4. ERICSSON with 98
5. INTEL with 55
6. NOKIA with 30
7. ZTE with 27

Cf next slide for key player respective positioning

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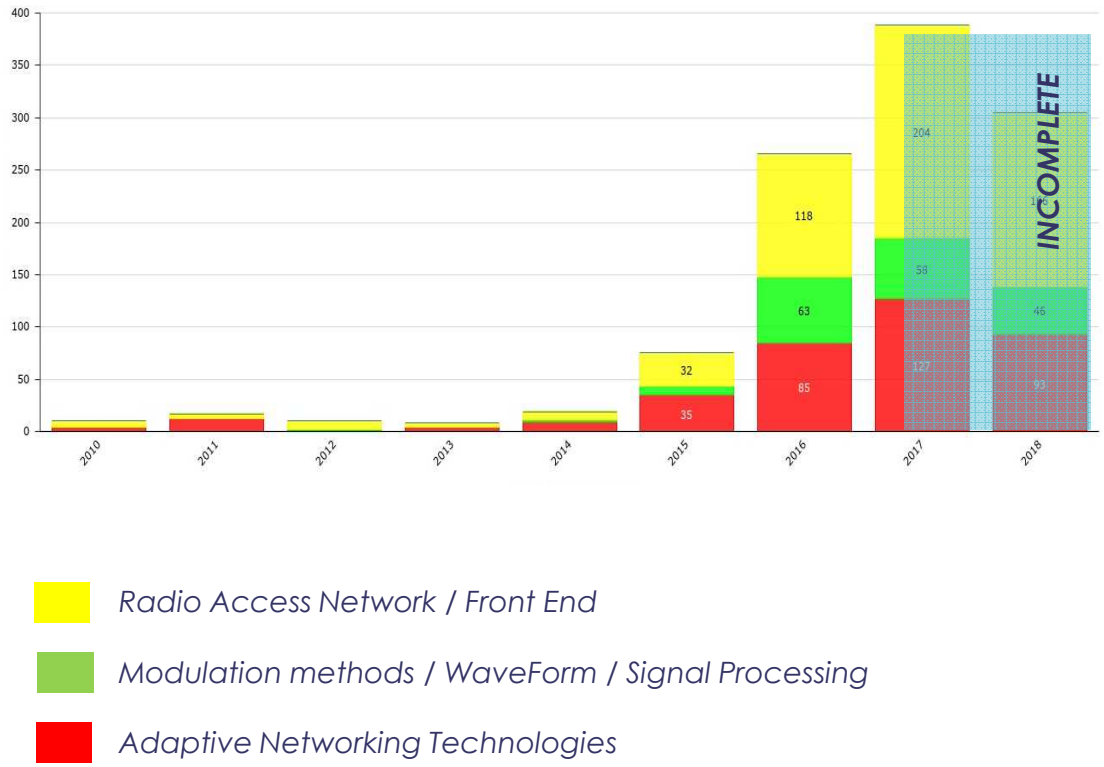
Technology Segments Evolution (Focus 5G only)

Macro Analysis

- The figure shows the growth of our 3 main technology segments up to '16
- The **RADIO ACCESS NETWORK** segment is growing fast due mainly to Multi Antenna/ Massive elements
- Dynamic Spectrum Mgt, Massive MIMO adoption & beam forming is also a growing trend
- The **MODULATION & WF** segment is accelerating due to the recent R&D effort on Cognitive Radio and new modulations/WF technics LBT, BDMA, FBMC…
- **ADAPTIVE NETWORKING** segment is represents a large part of our selection due to massive R&D effort on SDN, NFV, Cloud-RAT and similar technologies applied to 5G
- **Fog/Multi Access Edge computing** are also a recent trend



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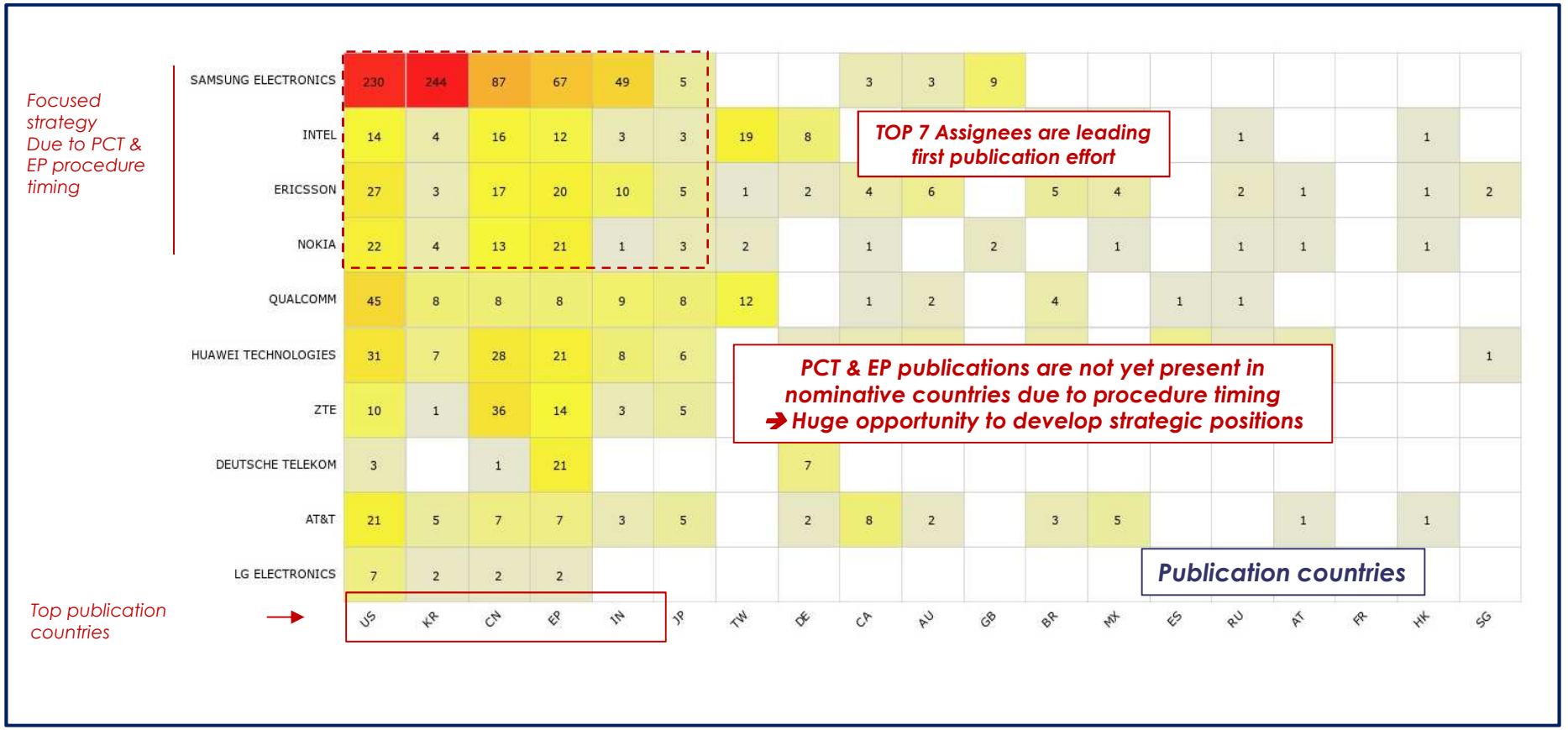
Geographical coverage by Top Assignees (Focus 5G only)



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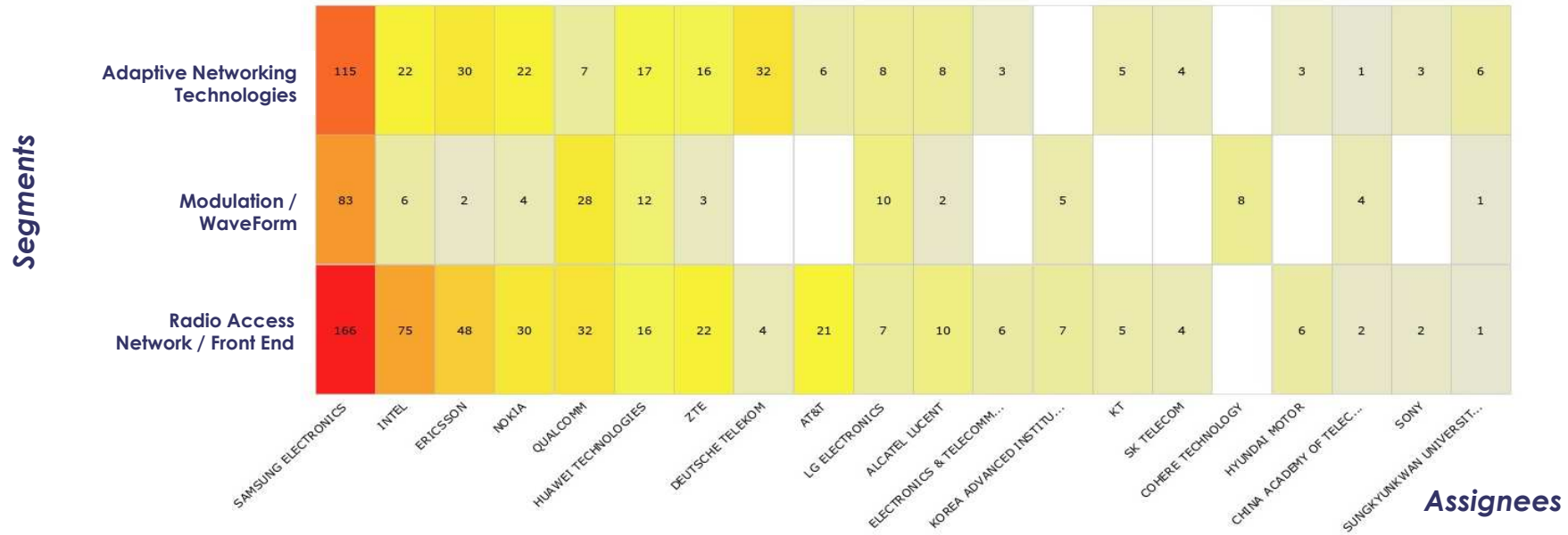
On which Segment Top assignees are investing ? (Focus 5G only)



- Samsung, Intel , Ericsson, Nokia & Qualcomm as Top assignees on **Radio Access Network / Front End**
- Huge presence of **Samsung and Qualcomm** on **new Modulation / WF for the 5G**
- Many actors investing on **Adaptive Networking Technologies**

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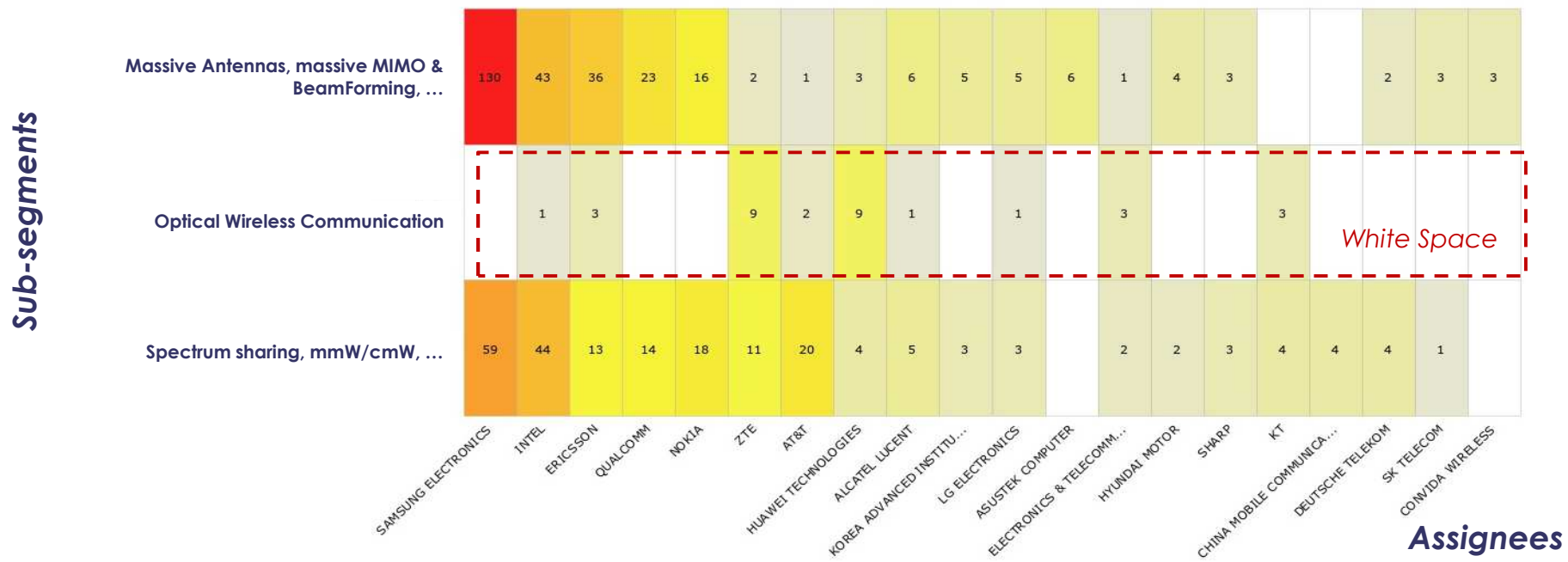
On which RADIO FRONT END "sub-segments" Top assignees are investing ?



- Samsung, Intel, Ericsson, Qualcomm & Nokia as Top assignees on **Multi Antennas, Massive Beam Forming / Massive MIMO**
- **Optical Wireless Communication** still a "White space" sub segment
- More assignees working on **Spectrum sharing & new mmW/cmW Frequencies usage**

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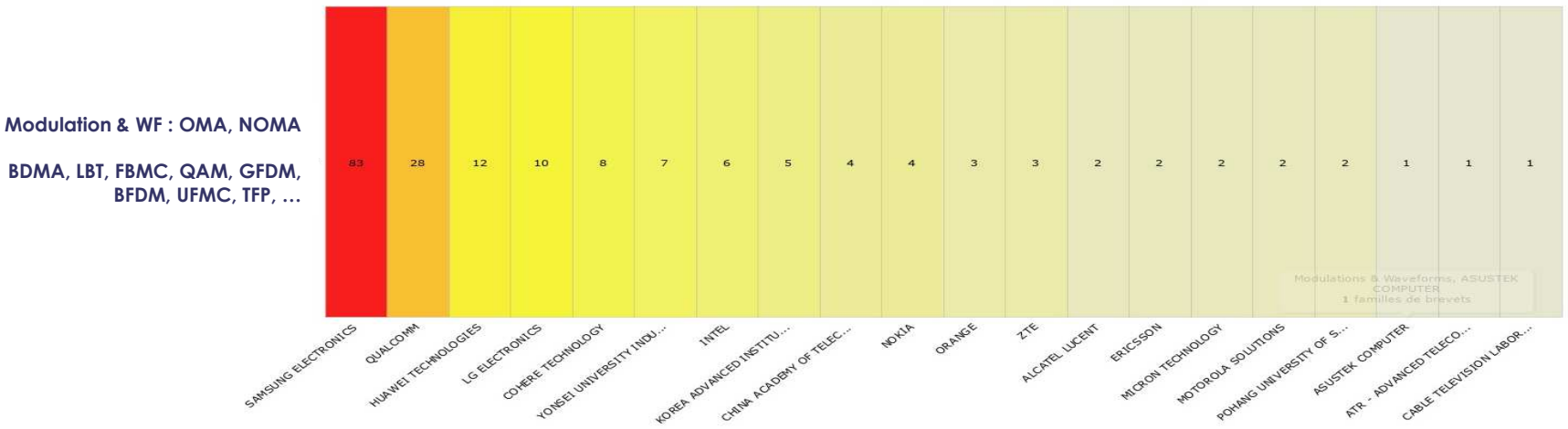
On which MODULATION/WF "sub-segments" Top assignees are investing ?



- **Samsung, Qualcomm** are leading this segment
- **New WF/modulations** such as *LBT, FBMC Filter Bank Multi Carrier and QAM Quadrature Amplitude Modulation* well represented
- **Still "White space" to develop new positions in particular regarding new WF for 5G**

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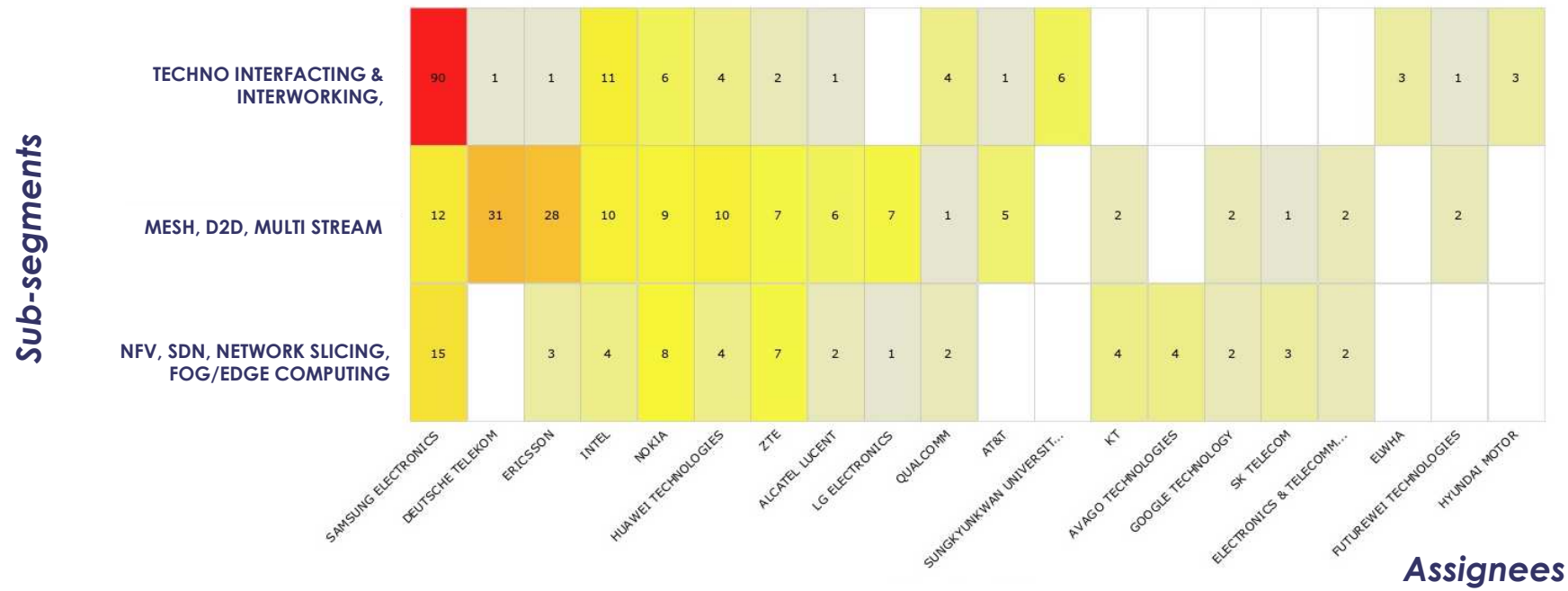
On which ADAPTIVE NETWORKING "sub-segments" Top assignees are investing ?



- **Samsung, Nokia, Zte** as Top assignees on **NFV, SDN, Network slicing new trends applied to 5G**
- **Ericson & DT** are leading **D2D** sub segment
- **Samsung** & Intel are leading Interfacing & Interworking technos (2G/3G/4G/WIFI/…)

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Conclusion

The study is not complete

Other early trends/technology shave to be considered

It is a starting point and could be enriched within the 5G PPP community in order to define pragmatic and pertinent KPIs