CORRIDOR

COgnitive Radio for high speed RAilway through Dynamic and Opportunistic spectrum Reuse

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afaq ISO 9001 Qualité AFNOR CERTIFICATION

System Definition and System Constraints (Task 3)

- **Task 3 is using results from Task 2** – « user needs for railway field » (« besoin des utilisateurs dans le domaine ferroviaire ») to establish system requirements;

- **The methodology used** was :
  - **to imagine** the use cases ;
  - **to analyze** the typical applications (already used or for further use) ;
  - **to translate** previous analysis into system characteristics such as bandwidth, latency, QoS classification..

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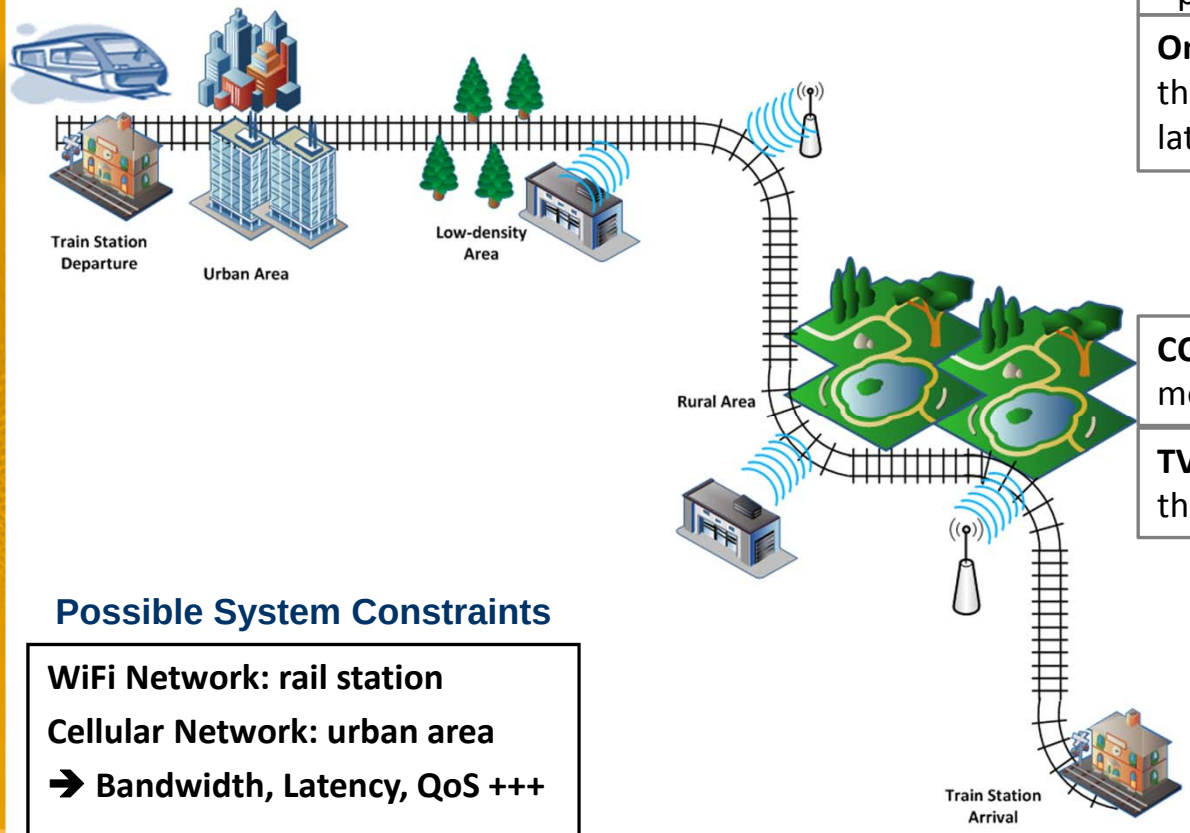
System Definition and System Constraints (Task 3)

- **Use Case :** Train at the Departure Station, Urban Area **(1/5)**



Possible Services

Download information at the train departure: high throughput - potentially medium latency.

On-board internet access: high throughput – potentially high latency.

CCTV Video: high throughput – medium latency.

TVSE Application: high throughput – low latency.

Possible System Constraints

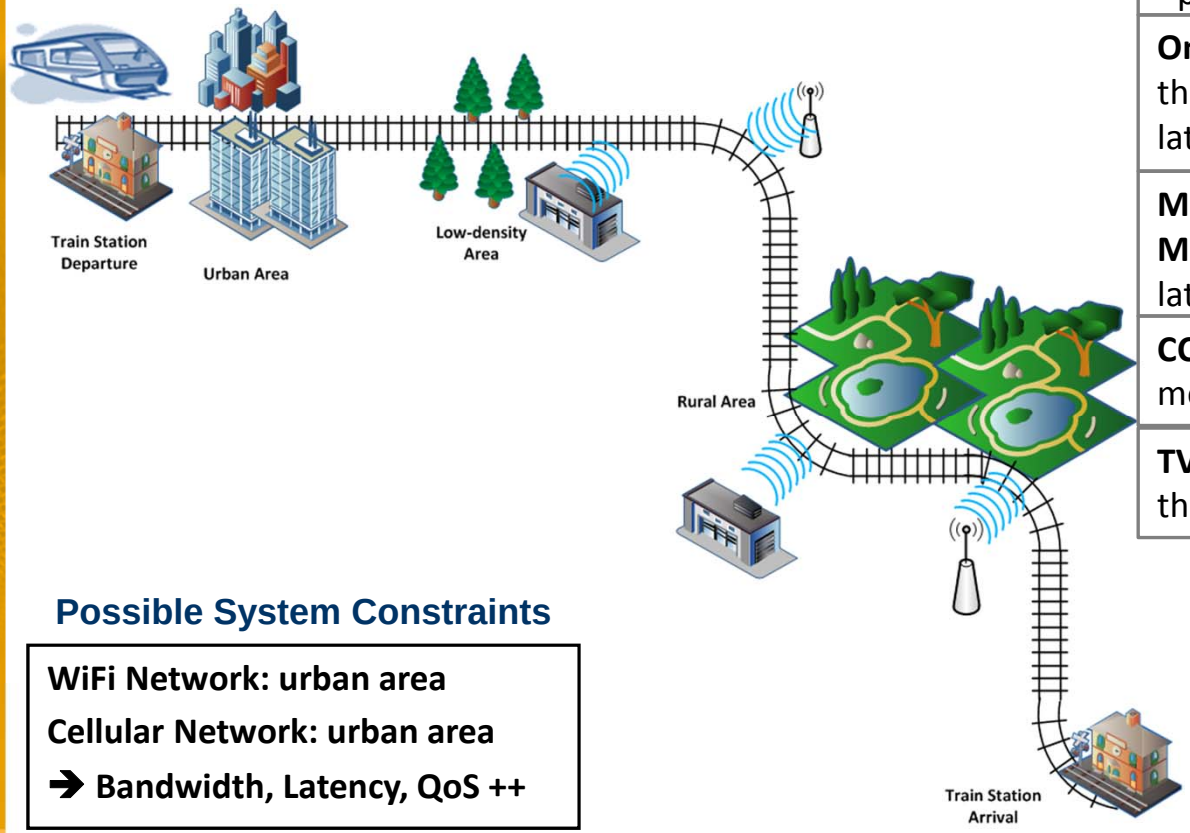
WiFi Network: rail station

Cellular Network: urban area

➔ **Bandwidth, Latency, QoS +++**

System Definition and System Constraints (Task 3)

- **Use Case :** Train after departure, Urban Area **(2/5)**



Possible Services

Download information at the train departure: high throughput - potentially medium latency.
On-board internet access: high throughput – potentially high latency.
Monitoring and Maintenance Messages: low throughput – high latency.
CCTV Video: high throughput – medium latency.
TVSE Application: high throughput – low latency.

Possible System Constraints

WiFi Network: urban area

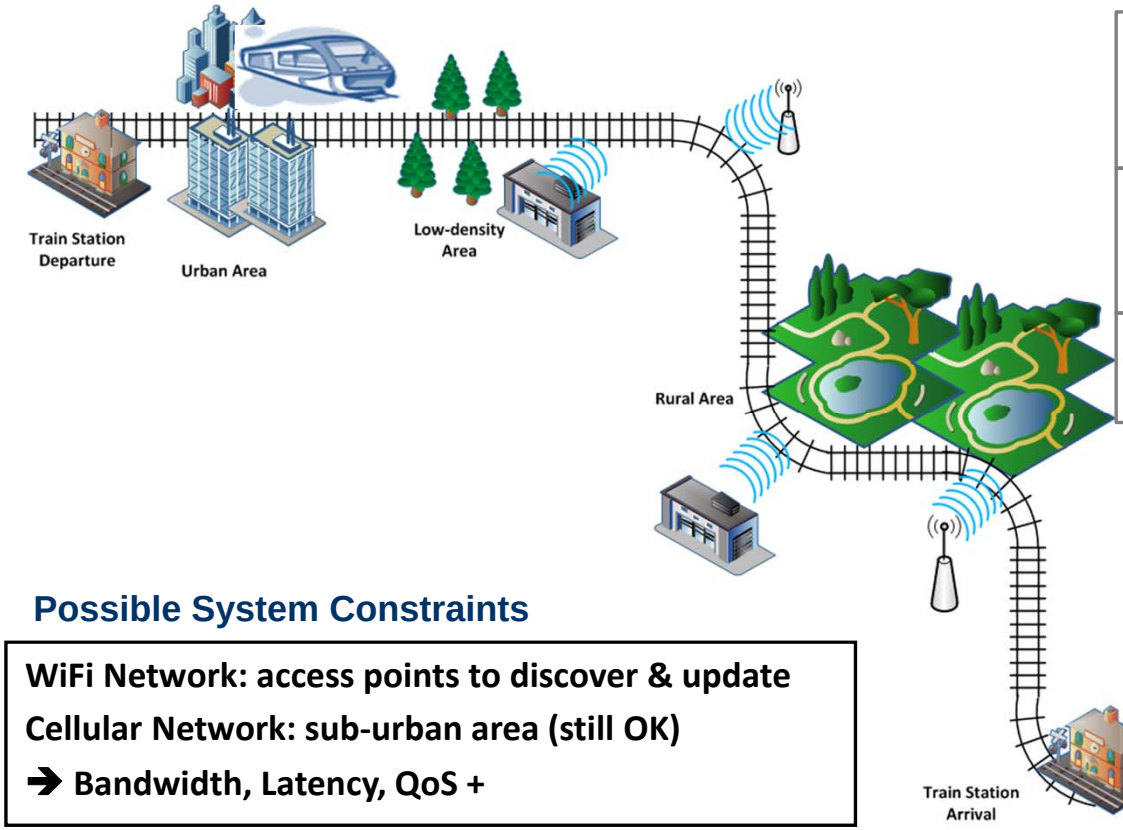
Cellular Network: urban area

➔ **Bandwidth, Latency, QoS ++**

System Definition and System Constraints (Task 3)

- **Use Case :** Train after departure, Sub-Urban Area **(3/5)**

Possible Services



On-board internet access: high throughput – potentially high latency.

Monitoring and Maintenance Messages: low throughput – high latency.

CCTV Video: high throughput – medium latency.

Possible System Constraints

WiFi Network: access points to discover & update

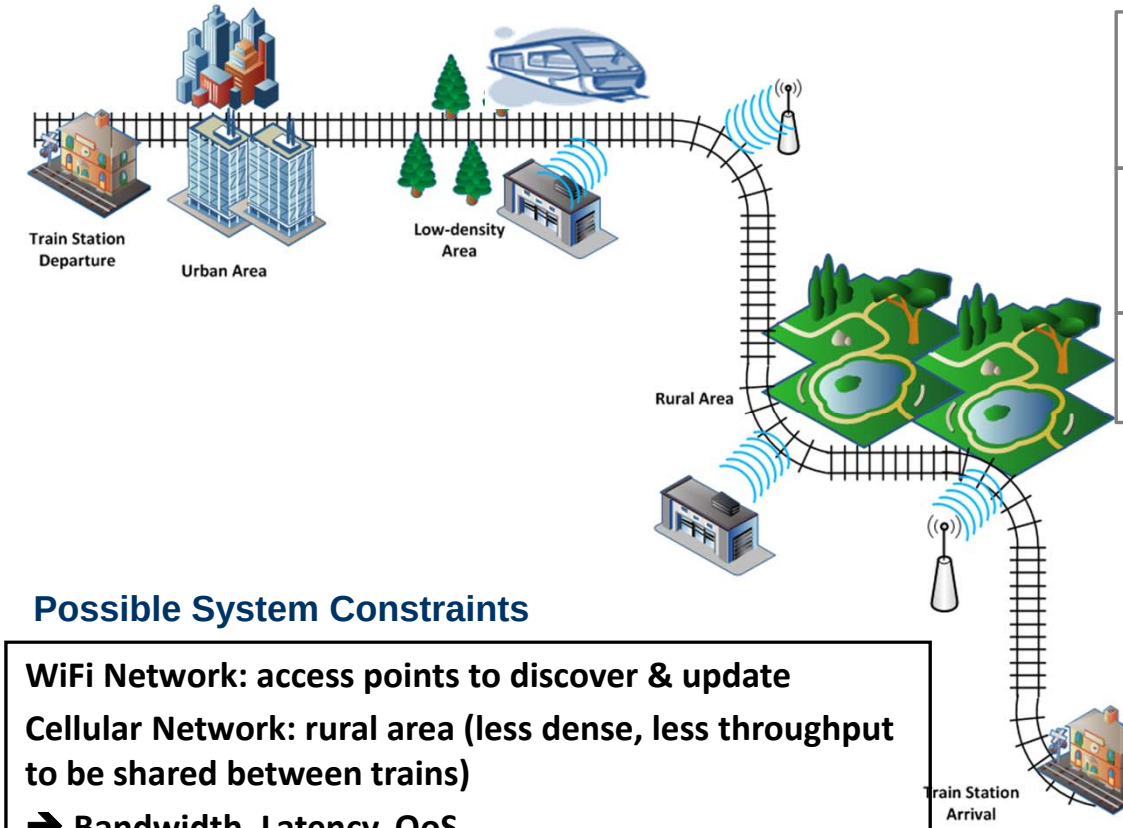
Cellular Network: sub-urban area (still OK)

➔ **Bandwidth, Latency, QoS +**

System Definition and System Constraints (Task 3)

- **Use Case :** Train after departure, Rural Area **(4/5)**

Possible Services



On-board internet access: high throughput – potentially high latency.
Monitoring and Maintenance Messages: low throughput – high latency.
CCTV Video: high throughput – medium latency.

Possible System Constraints

WiFi Network: access points to discover & update

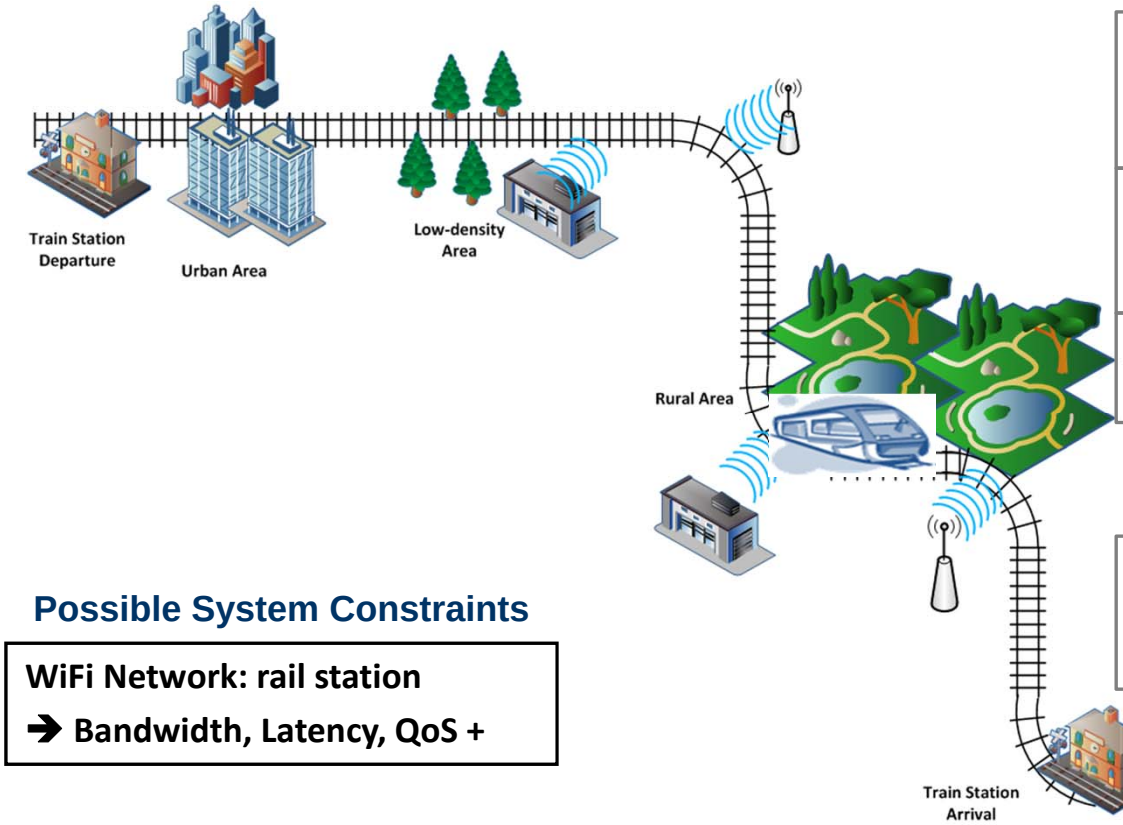
Cellular Network: rural area (less dense, less throughput to be shared between trains)

➔ **Bandwidth, Latency, QoS -**

System Definition and System Constraints (Task 3)

- **Use Case :** Train at the Arrival Station, Rural Area **(5/5)**

Possible Services



On-board internet access: high throughput – potentially high latency.

Monitoring and Maintenance Messages: low throughput – high latency.

CCTV Video: high throughput – medium latency.

Upload information at the train arrival: high throughput - potentially medium latency.

Possible System Constraints

WiFi Network: rail station

➔ **Bandwidth, Latency, QoS +**

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New Possible Services Requiring High Data Rates (see D3.1 & D3.2)

Traffic Type: UL (UpLink) or DL (DownLink)	Service Type (examples)*				Minimum Total Traffic for All Services (except normal user access)
	On-board Internet Access (business access only, during peak periods)	On-board Internet Access (normal user access only, during peak periods)	Train Video Surveillance (e.g. Closed Circuit TV or CCTV)	Semi-Embedded Video Transmission (TVSE Application) – for controlling doors.	
UL Minimum Required Traffic	2 Mbits/sec	90 Mbits/sec	1 Mbits/sec	512 Kbits/sec	**3,5 Mbits/sec**
DL Minimum Required Traffic	7 Mbits/sec	800 Mbits/sec	512 Kbits/sec	12 Mbits/sec	**19,5 Mbits/sec**

*** Other additional services might exist, e.g. for train control purposes (for operating the train) – but this would require very low data rate with very high priority.**

Current minimum required throughput needs are not satisfied by current technology.

LTE might be the answer but LTE has not been designed for high speed platforms and has to be evaluated and modified accordingly.

Diapositive 8

DP2 At the rail stations one can use WiFi to download and upload train information. Therefore this service will most probably not impact the cellular network side.

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QoS Requirements/Service (see D3.1 & D3.2)

QoS Requirements	Service Type (examples)*		
	On-board Internet Access (business access only)	Train Video Surveillance (e.g. Closed Circuit TV or CCTV)	Semi-Embedded Video Transmission (TVSE Application) – for controlling doors.
First Connection Establishment Time	< 5 sec.	< 5 sec.	< 2 sec.
Connection Delay	< 5 sec.	< 5 sec.	< 300 ms
Delay Variation	< 1 sec.	< 40 ms (1 image Tx time)	< 40 ms (1 image Tx time)
Availability of Data Rate	Inside or outside tunnels, on all 4 TGV branches	Inside or outside tunnels, on all 4 TGV branches	Video cameras installed on the station platform
Packet Loss	Yes (Allowed)	No (Not allowed)	No (Not allowed)
Required Speed	Up to 320 km/h	Up to 320 km/h	0-10 km/h
# of Users Sharing the Same Connection	100-150 users/train	Minimum 1 user/train (if only 1 camera is used at the time)	6 real-time video cameras/train

*** Other additional services might exist, e.g. for train control purposes (for operating the train) – but this would require very low data rate with very high priority, so throughput is not a problem for other additional services. However, the prioritization and the differentiation of data flow should be reconsidered.**

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What LTE Technology Could Offer in terms of Data Rate

LTE Capacity [Mbits/sec.] (FDD, 1 RF chain)

Mod. order	MCS/TBS Index**	1.25 MHz (6 RBs)	2.5 MHz (12 RBs)	5.0 MHz (25 RBs)	10.0 MHz (50 RBs)	15.0 MHz (75 RBs)	20.0 MHz (100 RBs)
2	0/0	0,152	0,328	0,68	1,384	2,088	2,792
	4/4	0,408	0,84	1,8	3,624	5,352	7,224
	9/9	0,936	1,864	4,008	7,992	11,832	15,84
4*	10/9	0,936	1,864	4,008	7,992	11,832	15,84
	13/12	1,352	2,728	5,736	11,448	16,992	22,92
	16/15	1,8	3,624	7,736	15,264	22,92	30,576
6	17/15	1,8	3,624	7,736	15,264	22,92	30,576
	23/21	2,984	5,992	12,576	25,456	37,888	51,024
	28/26	4,392	8,76	18,336	36,696	55,056	75,376

Without any other enhancements, LTE could theoretically allow some of the required services.

However, LTE has not been sufficiently tested in extreme scenarios e.g. for use with TGVs.

** Usual transmission/reception situation, 16 QAM modulation is involved*
*** MCS and TBS indexes taken from Table 7.1.7.1-1 [3GPP TS 36.213 V9.2.0 (2010-0-)]*