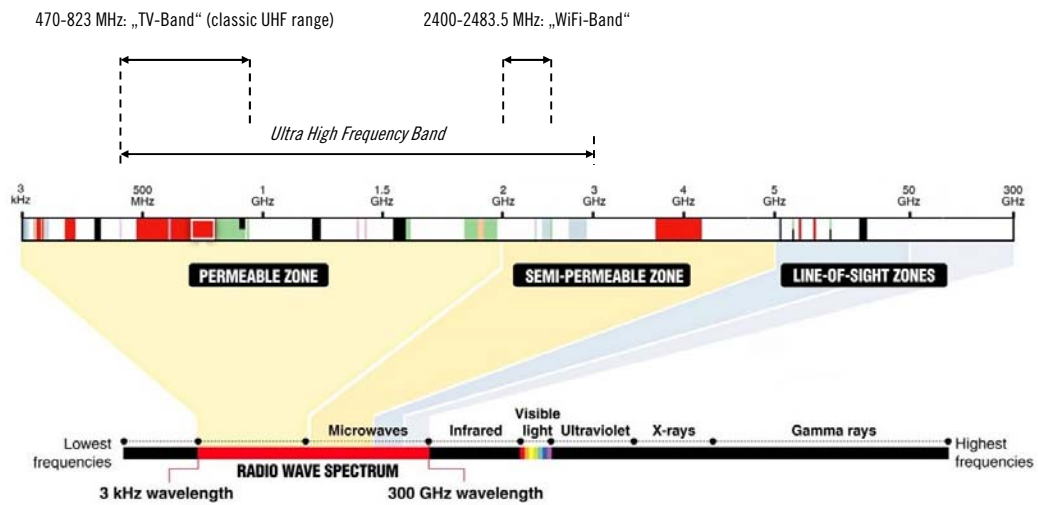


# 2.4GHz „Wi-Mi“-Systems

Management workflow and setup suggestions

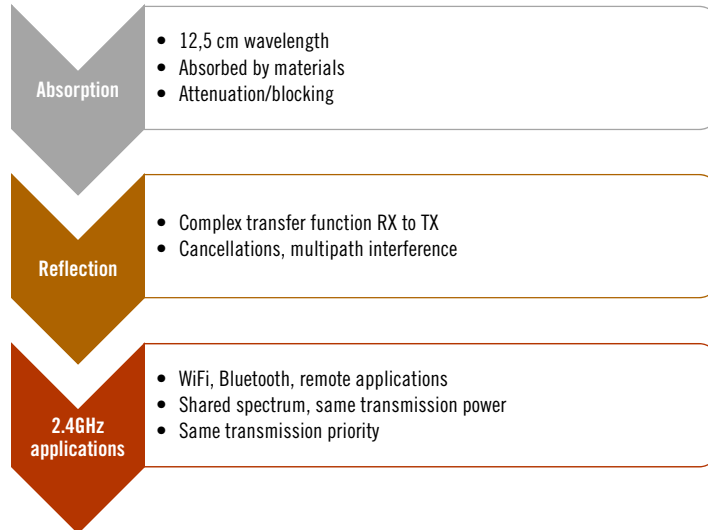
Andreas Juwan  
Ron Bakker  
Yamaha Music Europe GmbH

## Introduction



## WiMi system design *challenges*

tmt29  
expertise in audio media



YAMAHA

LENING

## System scope

tmt29  
expertise in audio media

### 2.4GHz ISM band:

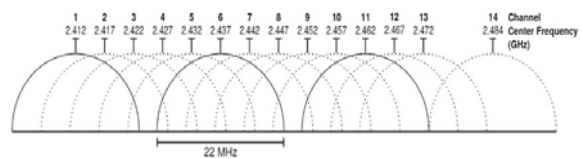
- 2400 – 2500 MHz (100 MHz bandwidth)
- Shared spectrum
- License free worldwide, general allocation

### WiFi:

- 14 channels (center freq.)
- 22 MHz width, 5 MHz distance
- CH 1, 6, 11: no overlap/interference

### WiMi:

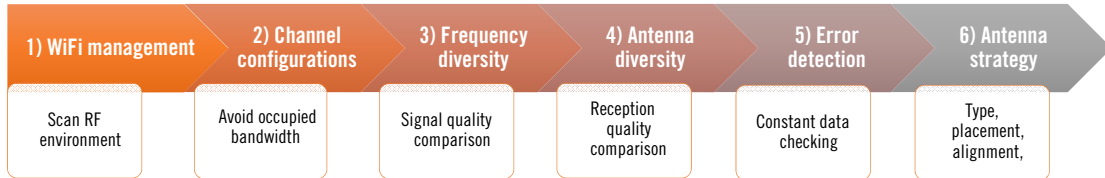
- Utilize same frequency range as WiFi
- We have to co-exist



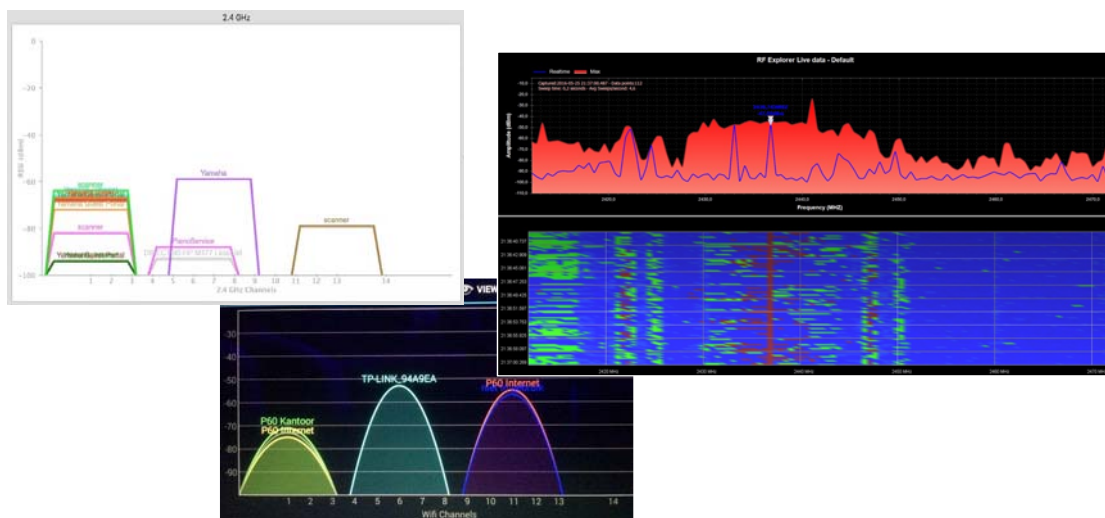
YAMAHA

LENING

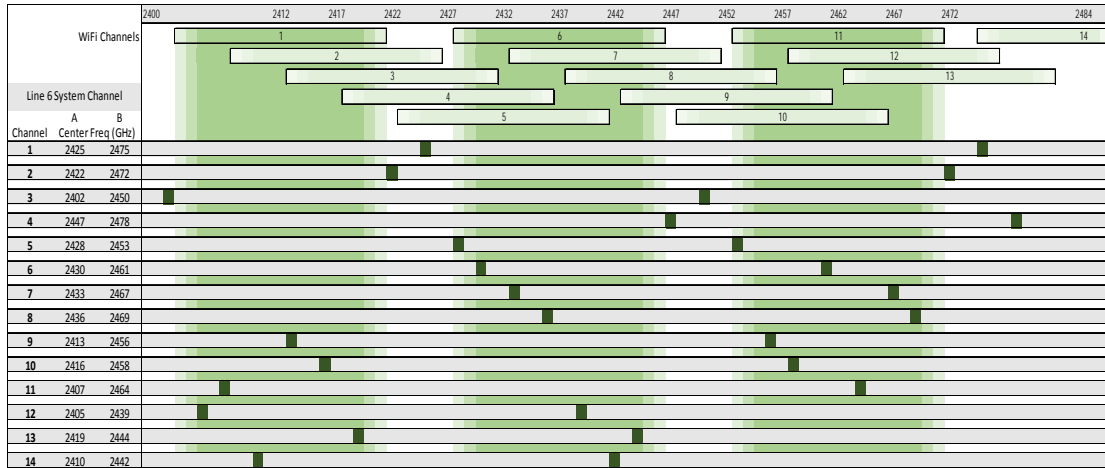
# WiMi system design *strategies* / Setup workflow



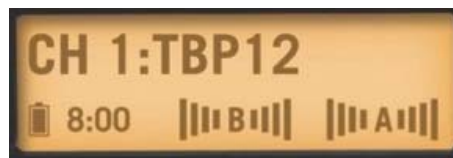
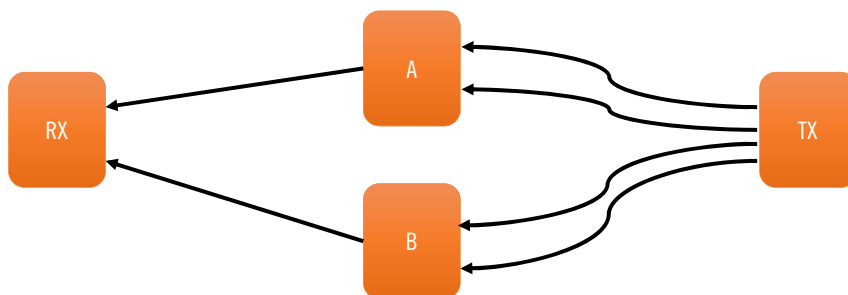
# WiFi & RF management



# Channel configurations

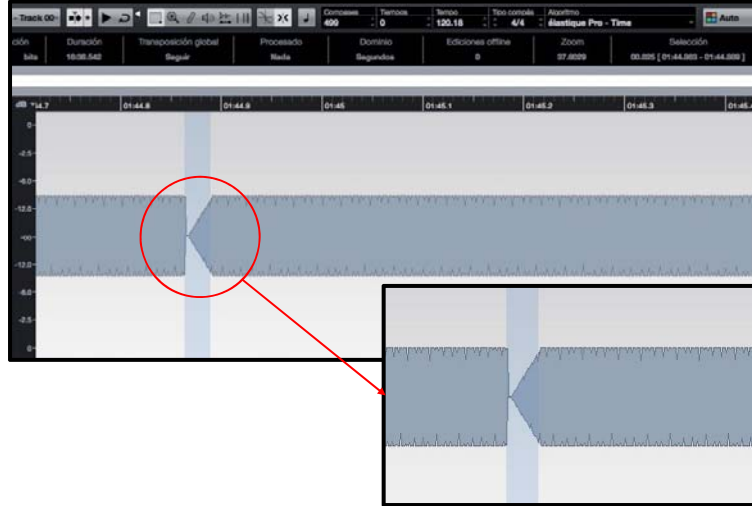


# Frequency diversity / Antenna diversity



## Error detection & correction fading

tmt29  
expertise in audio media

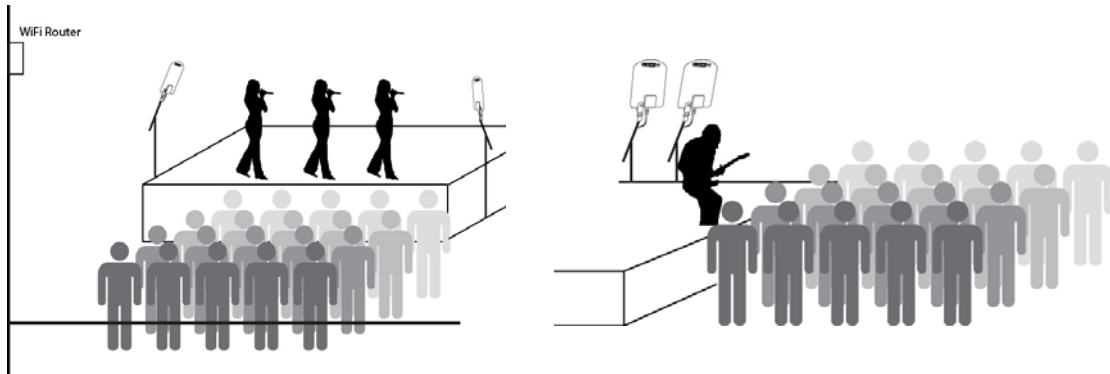


YAMAHA

EXTREME

## Antenna system design

tmt29  
expertise in audio media



YAMAHA

EXTREME

## Test sessions: Confirming strategies

tmt29  
expertise in audio media

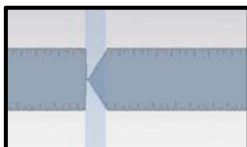
- 1) Varying conditions
- 2) Adding WAP
- 3) The "Facebook" Sessions

YAMAHA

LEINE

## Test sessions: confirm strategies

tmt29  
expertise in audio media



Quantifier:  $Q$  = Total drop-outs for all scenarios

*INCLUDING INAPPROPRIATE SCENARIOS, PROVOKING DROP-OUTS BY SABOTAGE !*

$$Q = \sum (Q_{\text{DIRECTIVITY}} + Q_{\text{DIVERSITY}} + Q_{\text{ROTATION}} + Q_{\text{BLOCKING}} + Q_{\text{ENVIRONMENT}} + Q_{\text{DISTANCE}})$$

$Q_{\text{DIRECTIVITY}}$	<i>variable:</i>	...using omni vs directional antenna
$Q_{\text{DIVERSITY}}$	<i>variable:</i>	...disabling one antenna
$Q_{\text{ROTATION}}$	<i>variable:</i>	...static position vs rotation
$Q_{\text{BLOCKING}}$	<i>variable:</i>	...block path with guitarist + guitar (SG300)
$Q_{\text{ENVIRONMENT}}$	<i>variable:</i>	...outside & inside
$Q_{\text{DISTANCE}}$	<i>variable:</i>	...distance between transmitter and antennas

YAMAHA

LEINE

# Session 1: distance, path, line of sight

tmt29  
expertise in audio media



Rotating platform



Antenna set-up



Receiver rack

YAMAHA

LEND

# Session 1: Distance, environment, line-of-sight

tmt29  
expertise in audio media

Outside session



Inside session



YAMAHA

LEND

## Total error counts for all scenarios

tmt29  
expertise in audio media

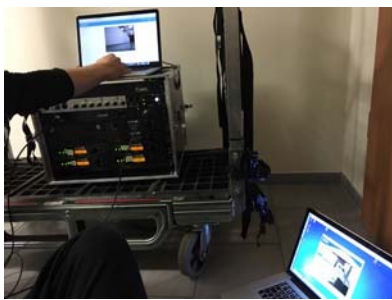
Variable	Conditions	
Directivity	directional	40
	omnidirectional	124
Diversity	dual	38
	single	104
Rotation	static	54
	rotation	114
Blocking	free	41
	blocked	127
Environment	outside	148
	inside	239
Distance	0-25m	67
	35-65m	318

YAMAHA

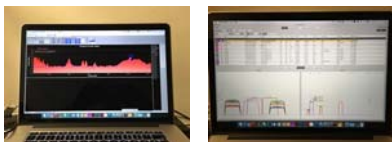
LEND

## Session 2: The effect of WiFi

tmt29  
expertise in audio media



IP-Video connections over WAP



RF and WiFi monitoring



Set-up

YAMAHA

LEND



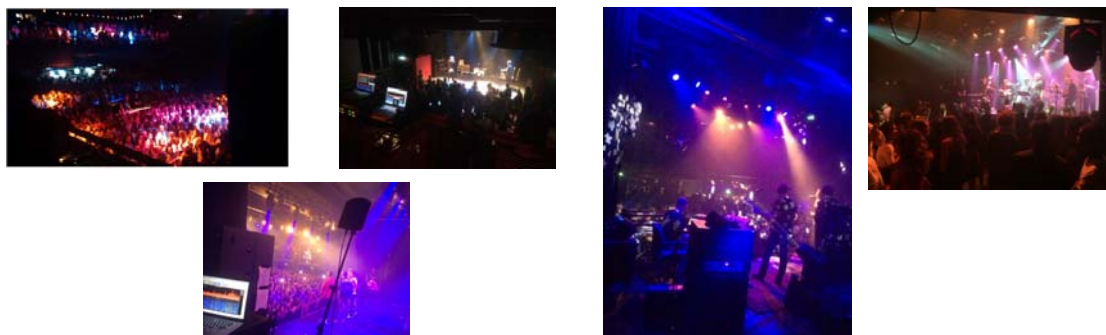
## Session 2: Test results



	Distance to antennas	Line6 Channel 6				Line6 Channel 1			
		single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180
no WAP	X	0	0	0	0	0	0	0	0
WAP behind antennas	5	9	12	0	0	0	0	0	0
WAP between antennas & transmitter	10	6	4	22	59	0	0	2	0
WAP behind transmitters	20	4	4	2	2	0	0	0	0



## Session 3: "The Facebook sessions"

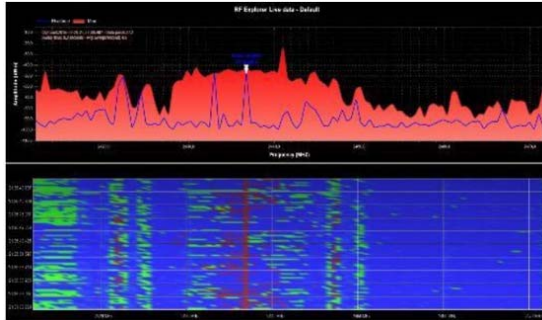


Venue	Band	Audience
Patronaat, Haarlem: Chef Special	Rock band: drums, guitar, bass, keyboard, vocals	1000
Melkweg, Amsterdam: B-Brave	Boy band, 5 boys	1000
P60, Amstelveen: InFloyd	Tribute band: drums, guitar, bass, keyboard, vocals	500
Paard van Troye, The Hague: Daddy Long Legs	Bluegrass band: drums, guitar, harmonica	150
Alster Open Air, Hamburg: Die PanikExperten	rock band: drums, 2 guitars, bass, keyboard, 3 vocals	500-700

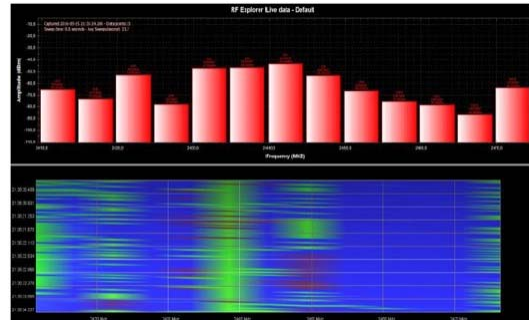


## Session 3: Facebook posts

tmt29  
expertise in audio media



RF energy (average/peak) on 2.4 GHz spectrum



Occupation of WiFi channels 1-14

Recorded @ Patronaat, Haarlem (NL)

- 1100 Visitors
- Public WiFi on Ch. 6

YAMAHA

LENOVO

## Conclusions

tmt29  
expertise in audio media

- WiMi systems support a limited amount of channels – even in congested WiFi environment
- WiMi systems provide drop-out free connections at full audio quality under strict quality management:
  - Always use antenna and frequency diversity systems
  - Always use directional antennas
  - Instruct performers to keep line of sight
  - Instruct performers not to cover transmitter's antennas
  - Control & manage WAP environment (RF scanner/WiFi scanner)
- Standard WAP traffic is not a problem – even with many concert goers connected to WiFi

YAMAHA

LENOVO



Thanks for your attention.



## Measurements (inside)



Distance (m)	Total	static transmitter (free line of sight)				static transmitter (guitarist blocking)				rotating transmitter (free line of sight)				rotating transmitter (guitarist blocking)			
		single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
25	37	0	0	0	0	4 (X)	12	35 (X)	19	0	0	0	0	2	0	1	3
35	26	0	5	0	0	0	0	4	3	0	0	4	4	0	1	4	1
45	145	0	5	5	5	2	32	4	5	2	10	12	6	12	10	20	15
55	13	0	0	0	0	0	0	0	0	0	1	1	2	4	2	3	0
65	16	0	0	2	2	0	4	0	0	0	0	0	0	2	5	0	1



## Measurements (outside)



Distance (m)	Total	static transmitter (free line of sight)				static transmitter (guitarist blocking)				rotating transmitter (free line of sight)				rotating transmitter (guitarist blocking)			
		single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	5	0	0	0	0	0	0	0	0	2	0	0	0	2	0	1	0
25	25	0	0	0	0	0	9	0	0	2	0	2	0	3	0	9	0
35	22	0	0	0	0	0	0	0	0	7	2	0	2	4	3	4	0
45	35	0	0	0	0	10	0	0	0	2	4	6	0	10	1	2	0
55	30	0	0	0	0	3	0	0	0	0	5	0	0	15	5	2	0
65	31	0	0	0	0	6	0	6	0	2	5	0	0	4	2	6	0
100	177	0	22	0	0	(x)	17	(x)	6	22	47	14	0	(x)	49	(x)	0



## Measurements (WAP effect)



	Distance to antennas	Line6 Channel 6				Line6 Channel 1			
		single 12W	dual 12W	single P180	dual P180	single 12W	dual 12W	single P180	dual P180
no WAP	X	0	0	0	0	0	0	0	0
WAP behind antennas	5	9	12	0	0	0	0	0	0
WAP between antennas & transmitter	10	6	4	22	59	0	0	2	0
WAP behind transmitters	20	4	4	2	2	0	0	0	0

