

SITE SURVEY

- WLAN E

- REDES DE COMUNICAÇÃO

MÓVEL CELULAR

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Estrutura

Introdução

Frequências e Métricas Utilizadas

Site Survey de Rádio Frequência

Site Survey WLANFT

Site Survey em Telefonia Celular GSM

Conclusão

Introdução

- ❖ Como atender as demandas ?
- ❖ O que se deve levar em conta ?
- ❖ Onde colocar os pontos de acesso ?



- ❖ Levantamento de Projeto
 - Frequências
 - Mobilidade
 - Densidade Populacional
 - Local
 - Tipo de serviço oferecido
 - Atenuações

Faixa de Freqüências

faixa	desde	até	comprimento de onda
ELF	30 Hz	300 Hz	10^7 metros
VF	300Hz	3 KHz	10^6 metros
VLF	3KHz	30 KHz	10^5 metros
LF	30 KHz	300 KHz	10^4 metros
MF	300 KHz	3 MHz	10^3 metros
HF	3 MHz	30 MHz	10^2 metros
VHF	30 MHz	300 MHz	10 metros
UHF	300 MHz	3 GHz	1 metro
SHF	3 GHz	30 GHz	10^{-1} metros
EHF	30 GHz	300 GHz	10^{-2} metros
Ondas Milimétricas	acima de	300 GHz	10^{-4} metros
Raios Infravermelhos	10^{11} Hz	10^{15} Hz	$0,7 \cdot 10^{-6}$ metros
Luz visível	10^{15} Hz	10^{15} Hz	$0,4 \cdot 10^{-6}$ metros
Raios Ultravioletas	10^{15} Hz	10^{16} Hz	10^{-8} metros
Raios "X"	10^{17} Hz	10^{20} Hz	10^{-9} metros
Raios "Gama"	10^{19} Hz	---	10^{-13} metros
Raios "Cósmicos"	10^{22} Hz	---	10^{-14} metros

Faixas de Freqüências

- ❖ VHF: Very High Frequency
 - De 30 MHz até 300 MHz.
 - Rádio FM e TV aberta, desde o canal 2 até o canal 13.
- ❖ UHF: Ultra High Frequency
 - De 300 MHz até 3.000 MHz (ou 3 GHz)
 - Canais de TV UHF e canais para telefonia celular.
 - Inclui as redes WLAN da faixa de 2.4GHz
- ❖ SHF: Super High Frequency
 - Vai desde 3 GHz até 30 GHz.
 - Satélite Banda "C", Banda "Ku" e as freqüências para Radio
 - Incluir as redes WLAN na faixa de 5.8GHz

RADIO, TV E CELULAR E WiFi

FAIXA DE FREQUENCIAS	SERVIÇOS
20 a 20.000 Hz	Sons audíveis
530 a 1.600 KHz	Rádio AM: 107 canais de 10 KHz
54 a 70 MHz e 76 a 88 MHz	Televisão VHF: Canais 2,3,4 e 5,6
88 MHz a 108 MHz	Rádio FM: 99 canais de 200 KHz
174 a 216 MHz e 470 a 806 MHz	Televisão VHF: Canais 7 a 13 e 14 a 69
824 a 894 MHz	Telefonia Celular Banda "A" e "B"
896 a 3.000 MHz	Outros Serviços, inclui WiFi (2.4 GHz)
3,7 a 4,2 GHz	Descida de sinal de Satélite Banda "C"
5,150 a 5,825GHz	Outros Serviços, inclui WiFi (5.8 GHz)
5,925 a 6,425 GHz	Subida de sinal de Satélite Banda "C"
6,425 a 7,125 GHz	Sistema Digital
10,7 a 11,7 GHz	Rádio Digital
10,7 a 12,2 GHz e 13,75 a 14,8 GHz	Descida e Subida de sinal de Satélite Banda "Ku"
14,5 a 15,35 GHz	Rádio Digital

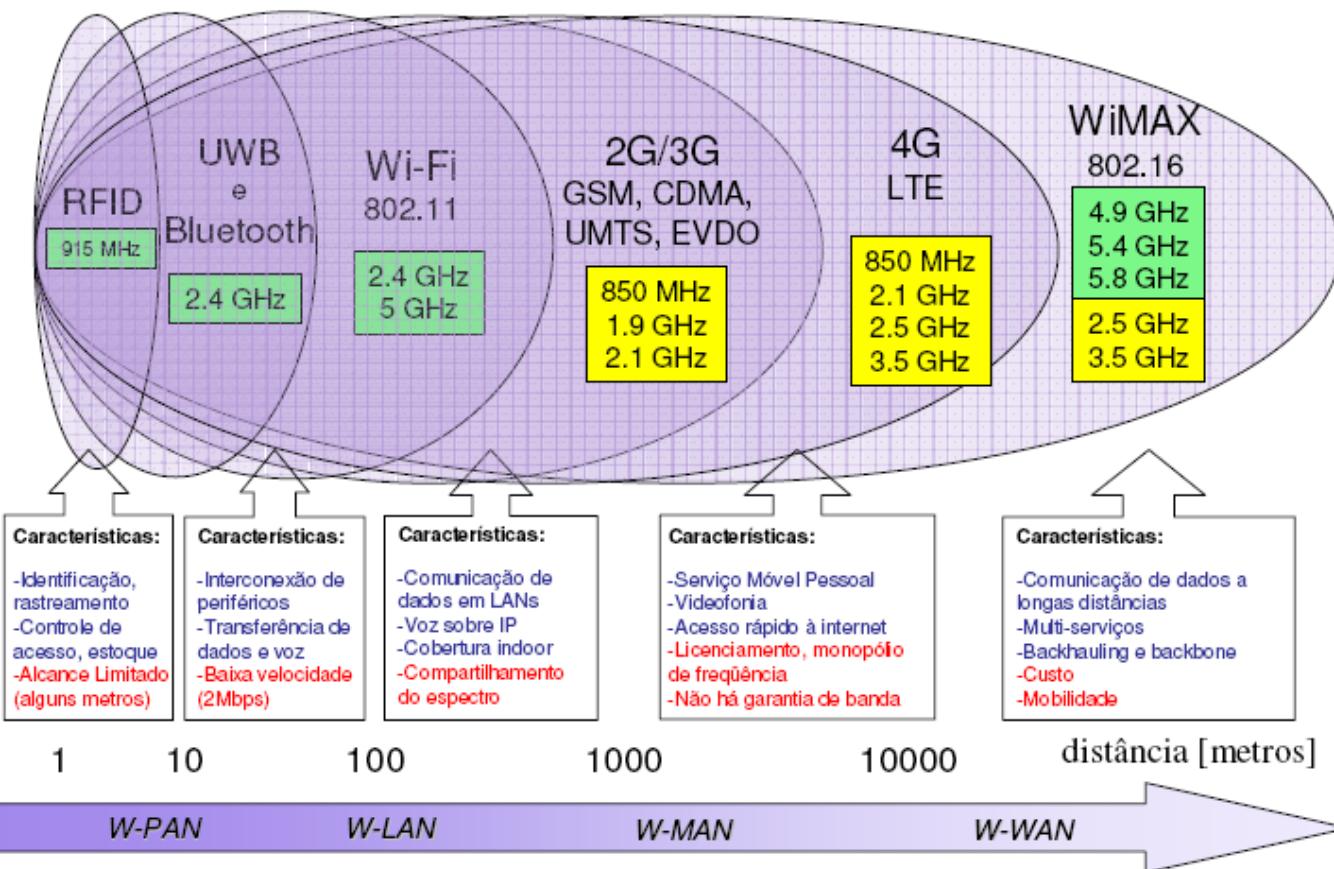
Padrões de Comunicação sem Fio

Fonte: INATEL

Tecnologias Wireless

LEGENDA

- [Verde] Freqüências Não Licenciadas
- [Amarelo] Freqüências Licenciadas



Freqüências não Licenciadas no Brasil

FAIXA DE FREQUENCIAS	INDOOR	OUTDOOR	Pmax (W)	Pmax (dBm)
902 a 907,5	SIM	SIM	4	36
915 a 928	SIM	SIM	4	36
2400 a 2483,5 Cidades > 500 mil hab.	SIM	SIM	0,4	26
2400 a 2483,5 Cidades <= 500 mil hab.	SIM	SIM	4	36
5150 a 5350	SIM	NÃO	0,2	23
5470 a 5725	SIM	SIM	1	30
5725 a 5825	SIM	SIM	4	36

Tecnologia Wi-fi

Freqüências disponíveis no Brasil

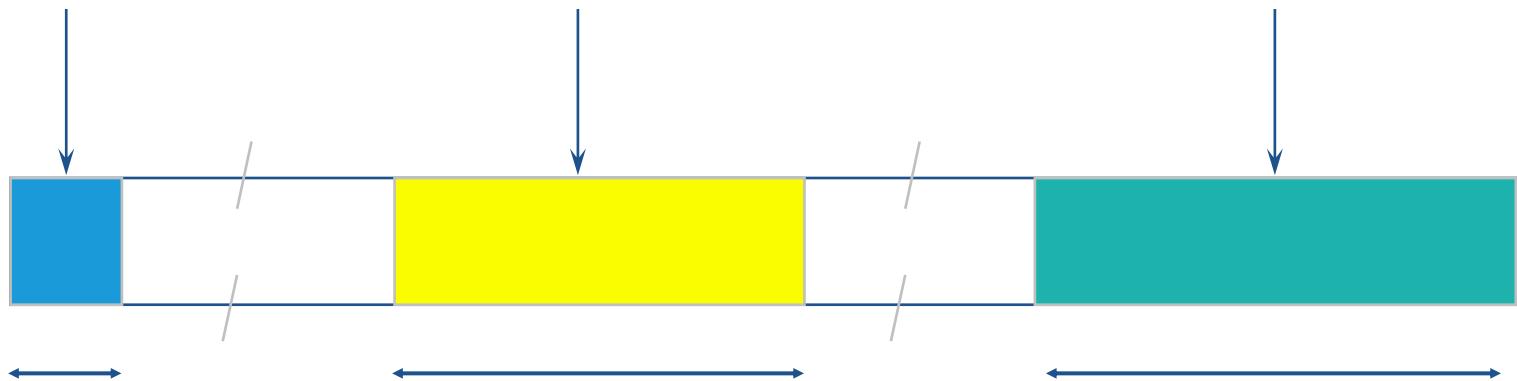
Freqüências (MHZ)	Condições de uso no Brasil
2400-2483 5725-5850	<ul style="list-style-type: none">- No Br, em caráter secundário, para Equipamentos de Radiocomunicação Restrita (Wi-Fi).- Uso em caráter primário: Serviço Auxiliar de Radiodifusão e Correlatos (SARC) e de Repetição de TV.<ul style="list-style-type: none">- A Anatel estabeleceu que sistemas (2400 MHz) em localidades com população superior a 500 mil habitantes e com potência (EIRP) superior a 400 mW não podem operar sem autorização da Anatel.
5150-5350 5470-5725	<ul style="list-style-type: none">- Sistemas de Acesso sem Fio em Banda Larga para Redes Locais.- 5150-5350 MHz: ambientes internos (indoor)- 5470-5725 MHz: ambientes externos e internos.

Freqüências utilizadas

915 MHz

2.45 Ghz

5.7875 Ghz



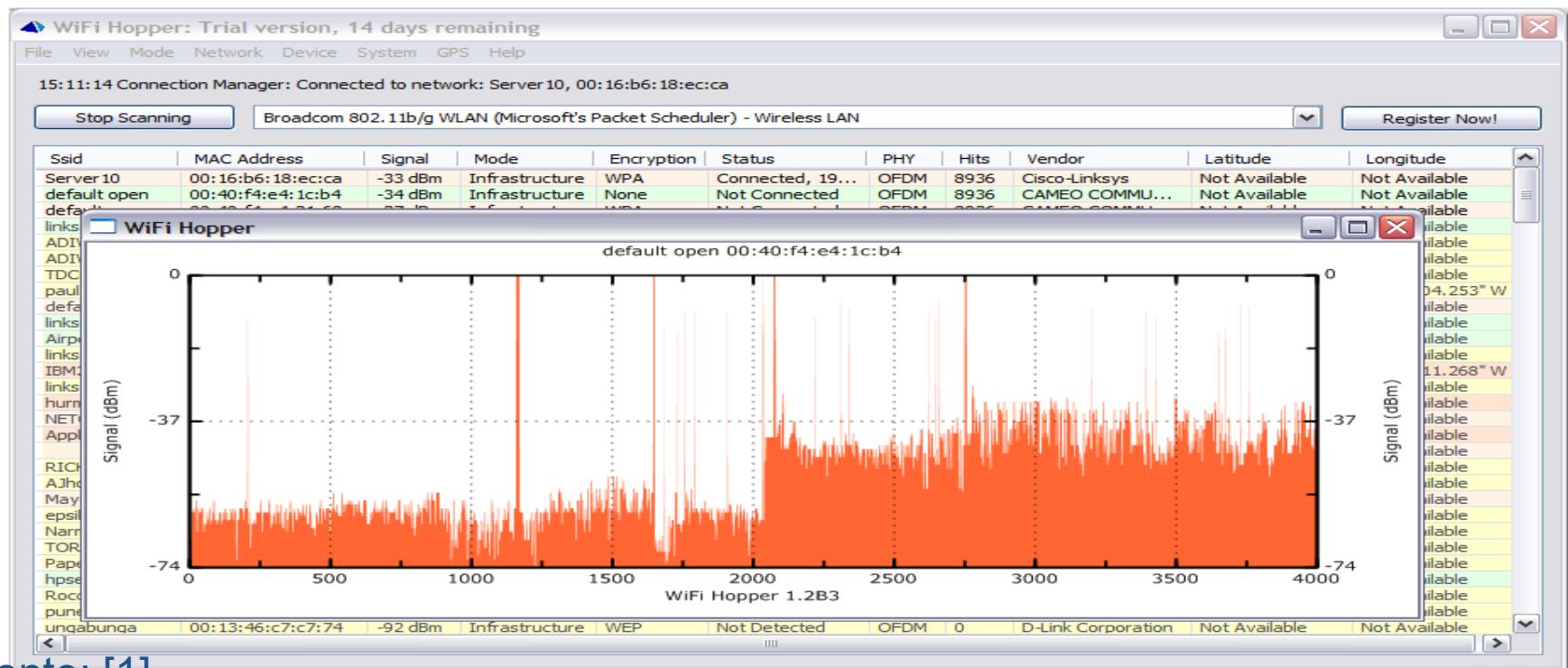
26 MHz
902-928

83.5 MHz
2400-2483,5

125 MHz
5725-5850

❖ Signal Strength

- mW
- dBm
- RSSI (Received Signal Strength Indication)



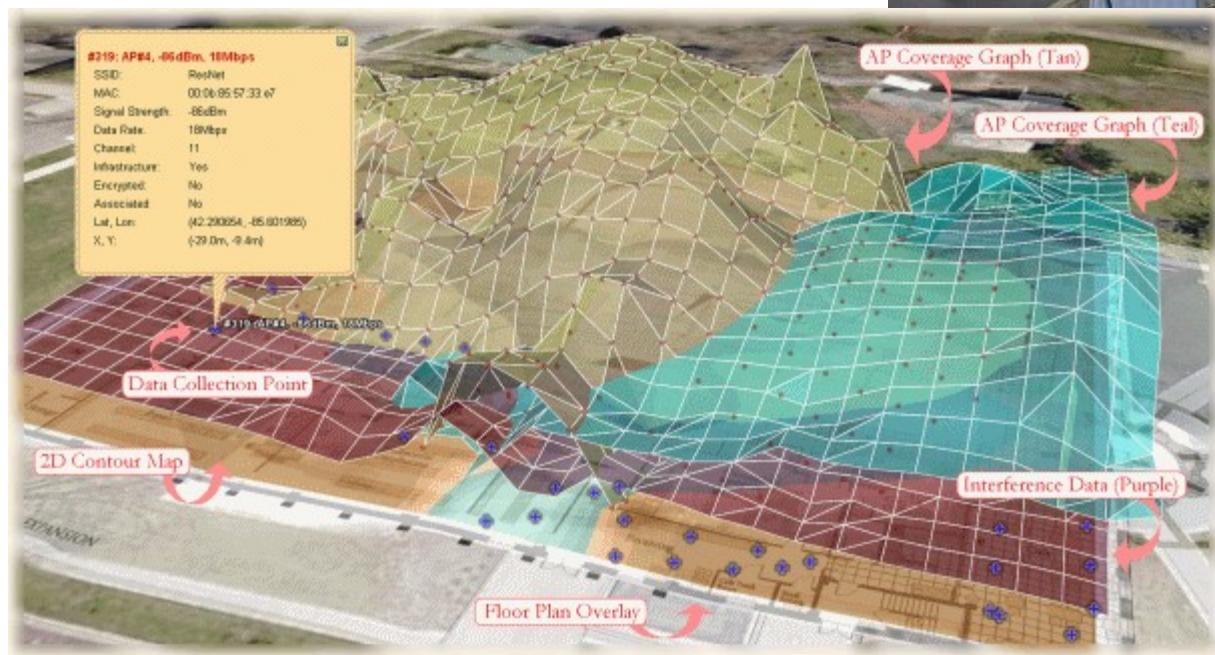
Fonte: [1]

❖ Signal to Noise Ratio (SNR)

SNR	Qualidade do Sinal	Associação	Velocidade
40dB	Excelente (5 barras)	Sempre	Máxima
25dB a 40dB	Muito bom (3-4 barras)	Sempre	Muito rápida
15db a 25dB	Baixa (2 barras)	Sempre	Usualmente rápida
10dB a 15dB	Muito baixa (1 barra)	Geralmente	Geralmente lento
5dB a 10dB	Sem sinal	Não	Nula

** Nível de ruído típico -90 dBm

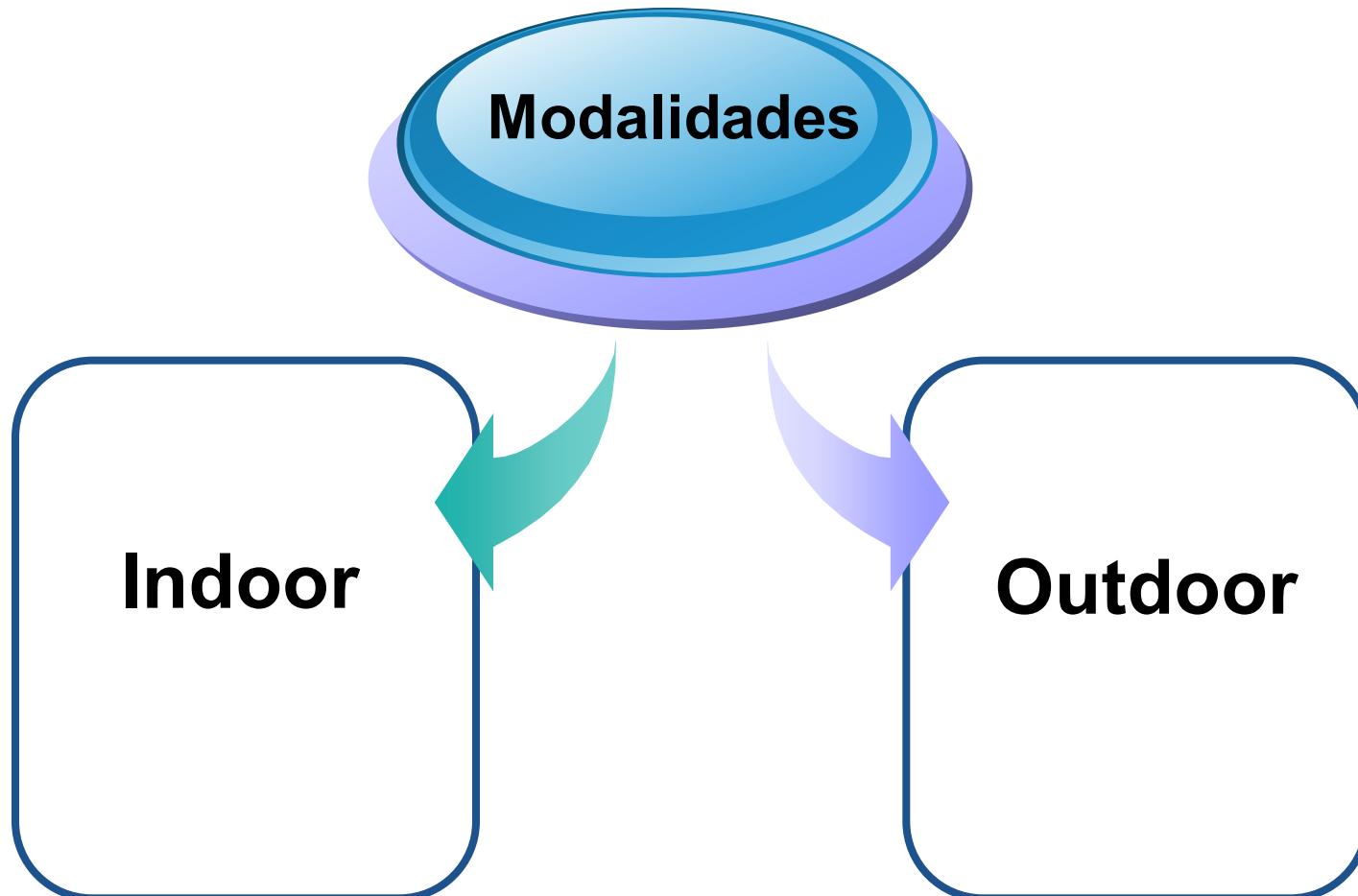
Site Survey



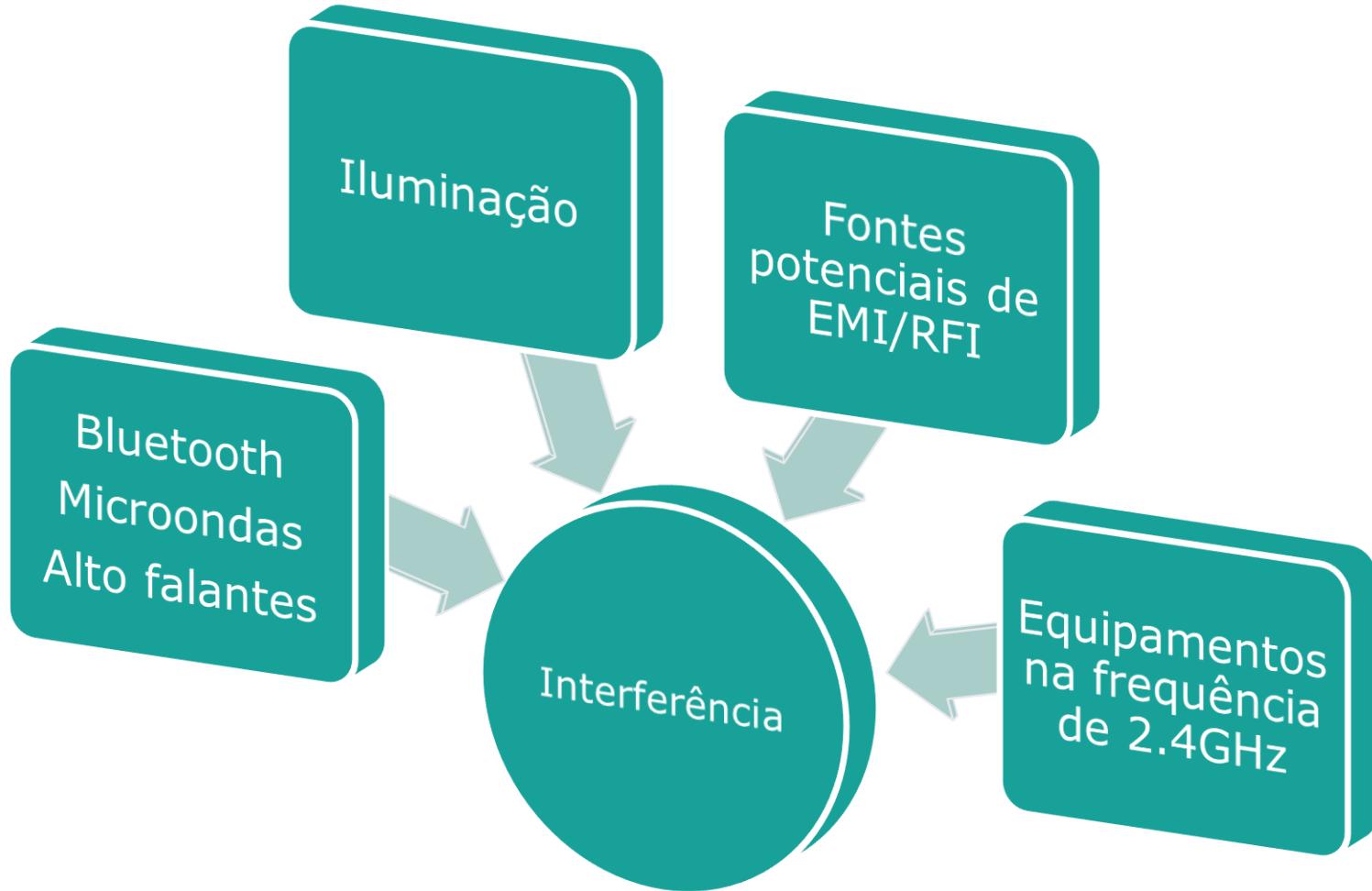
Site Survey



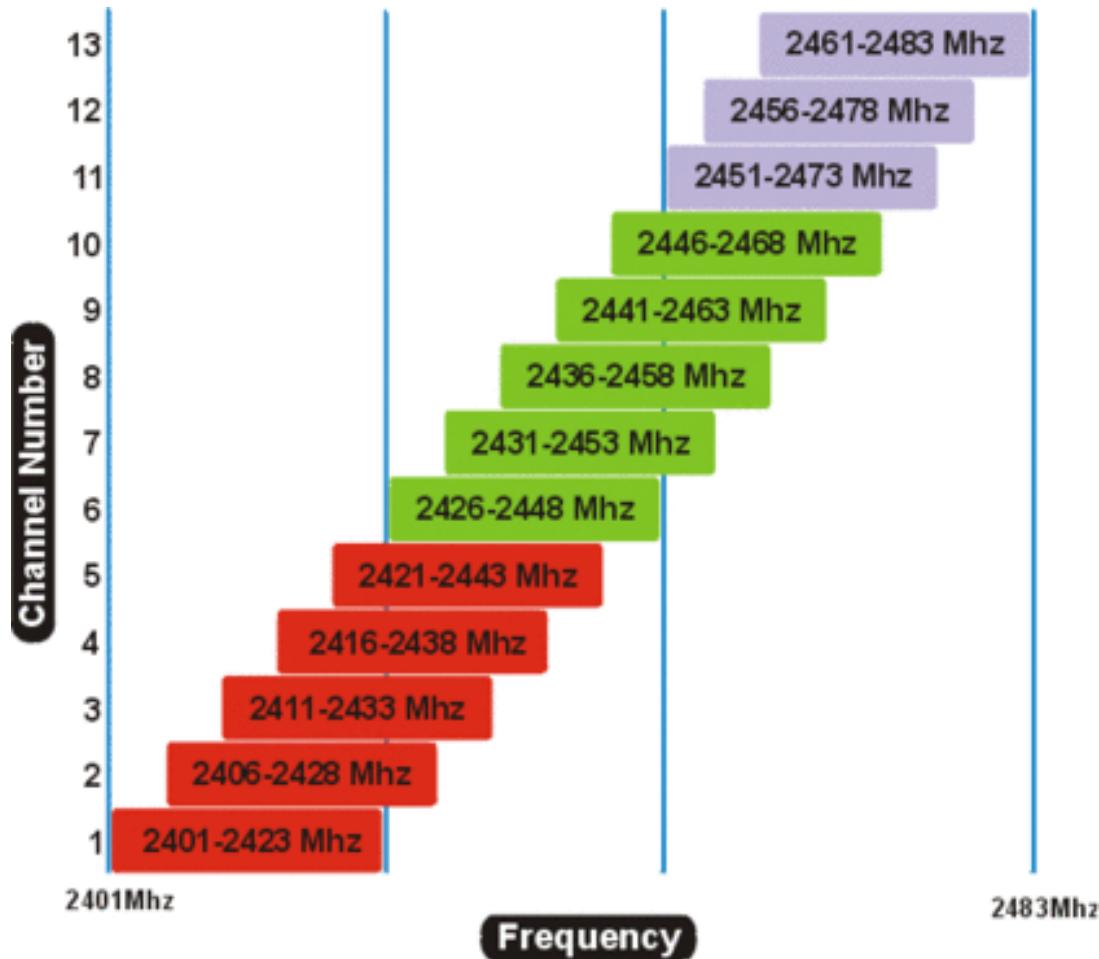
Site Survey



Site Survey



Site Survey



Barreiras e Possíveis Interferências

Tipo de barreira	Potencial de interferência
Madeira	Baixo
Gesso	Baixo
Materiais sintéticos	Baixo
Vidro	Baixo
Água	Médio
Tijolos	Médio
Mármore	Médio
Concreto	Alto
Vidro blindado	Alto
Metal	Muito alto

Vazão, Intensidade de Sinal e SNRmín

Data Rate (Mbps)	Data Cell		WIPT Cell	
	Minimum Cell Edge Signal Strength	Minimum SNR	Minimum Cell Edge Signal Strength	Minimum SNR
54	-71	25	—	—
36	-73	18	—	—
24	-77	12	—	—
12 or 11	-82	10	-67	25
6 or 5.5	-89	8	-74	23
2	-91	6	-76	21
1	-94	4	-79	19

Passos de um Site Survey

Obter um diagrama (pelo menos a planta baixa)

Inspecionar pessoalmente o local

Identificar utilização e diferenças de uso de banda no local

Determinar preliminarmente localização dos APs

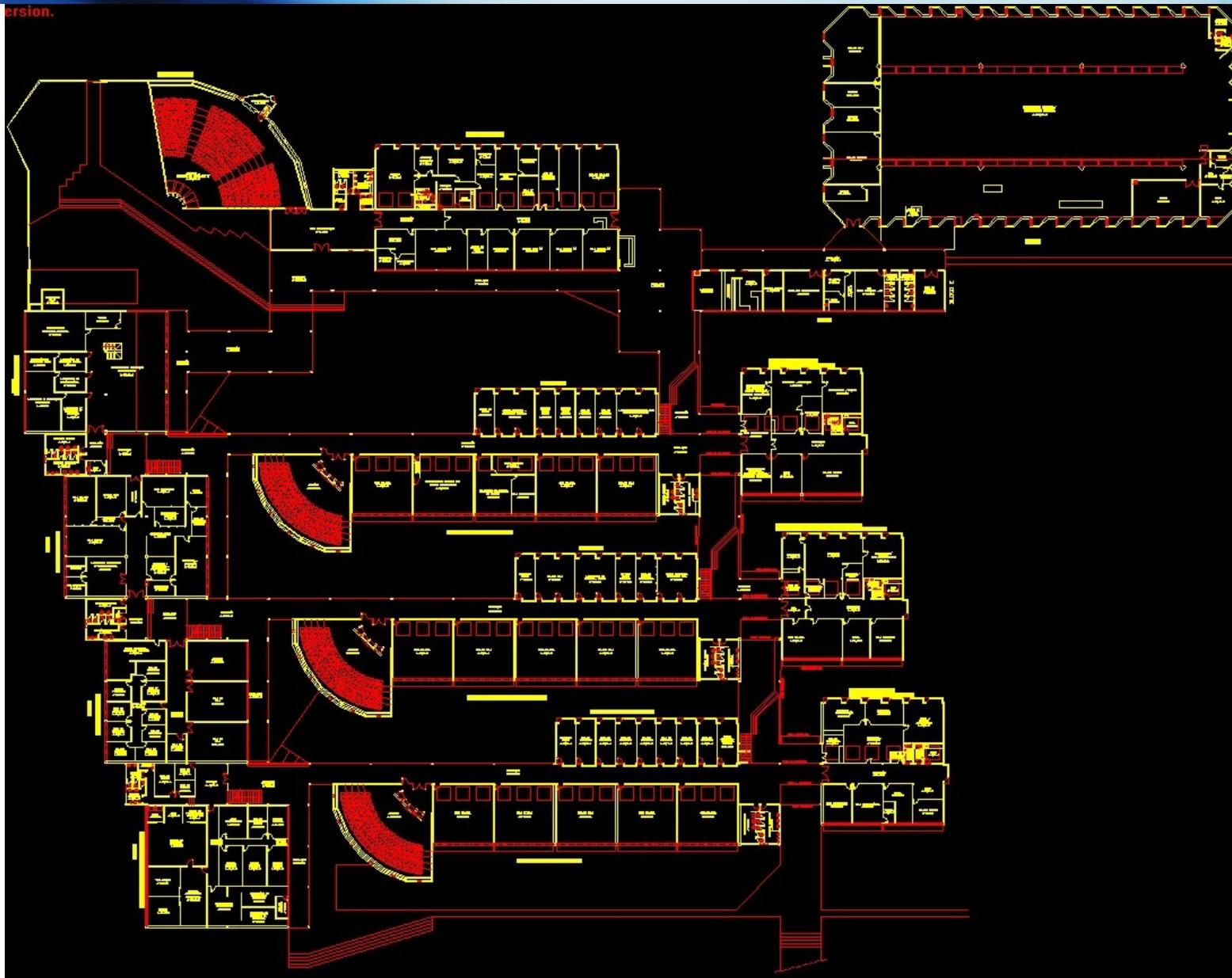
Realizar o real levantamento

Documentar

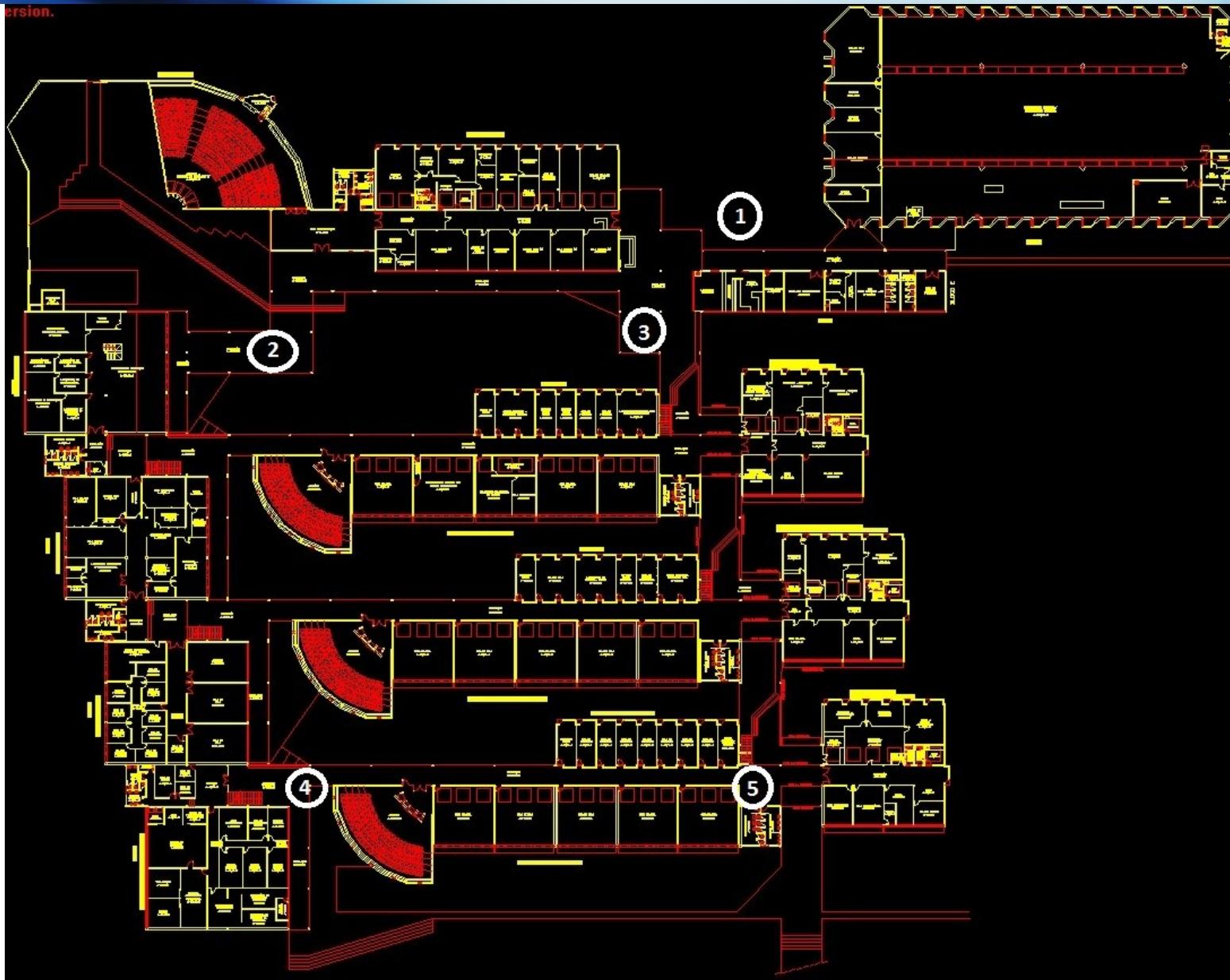
Alguns LEMBRETES (o mínimo...):

- ❖ planta baixa (pelo menos) e-ou Google Maps/G.Earth; GPS;
- ❖ identificar locais e período de coleta de dados;
- ❖ “*data sheets*” eqtos.considerados → características mais relevantes;
- ❖ diagrama de rede e normas específicas do local;
- ❖ descrever características da(s) ferramenta(s);
- ❖ abordar canalizações, tráfego(taxas de Tx, tipos,...), cobertura, interferência,métricas de QoS (BER, FER,...), segurança(padrões WEP, WPA,...), mobilidade (movimentação de usuários, taxa de handover, call drop rate, migração inter-redes...), escalabilidade (nr. máx usuários registrados e ativos por AP, possib. crescimento,...),coexistência de redes sem fio (bandas utilizadas), MIMO(reflexos?), integração WiFi-LTE?.
- ❖ mapas de calor (“heat maps”);
- ❖ verificar possíveis problemas de projeto;
- ❖ propor, sempre que possível, melhorias.

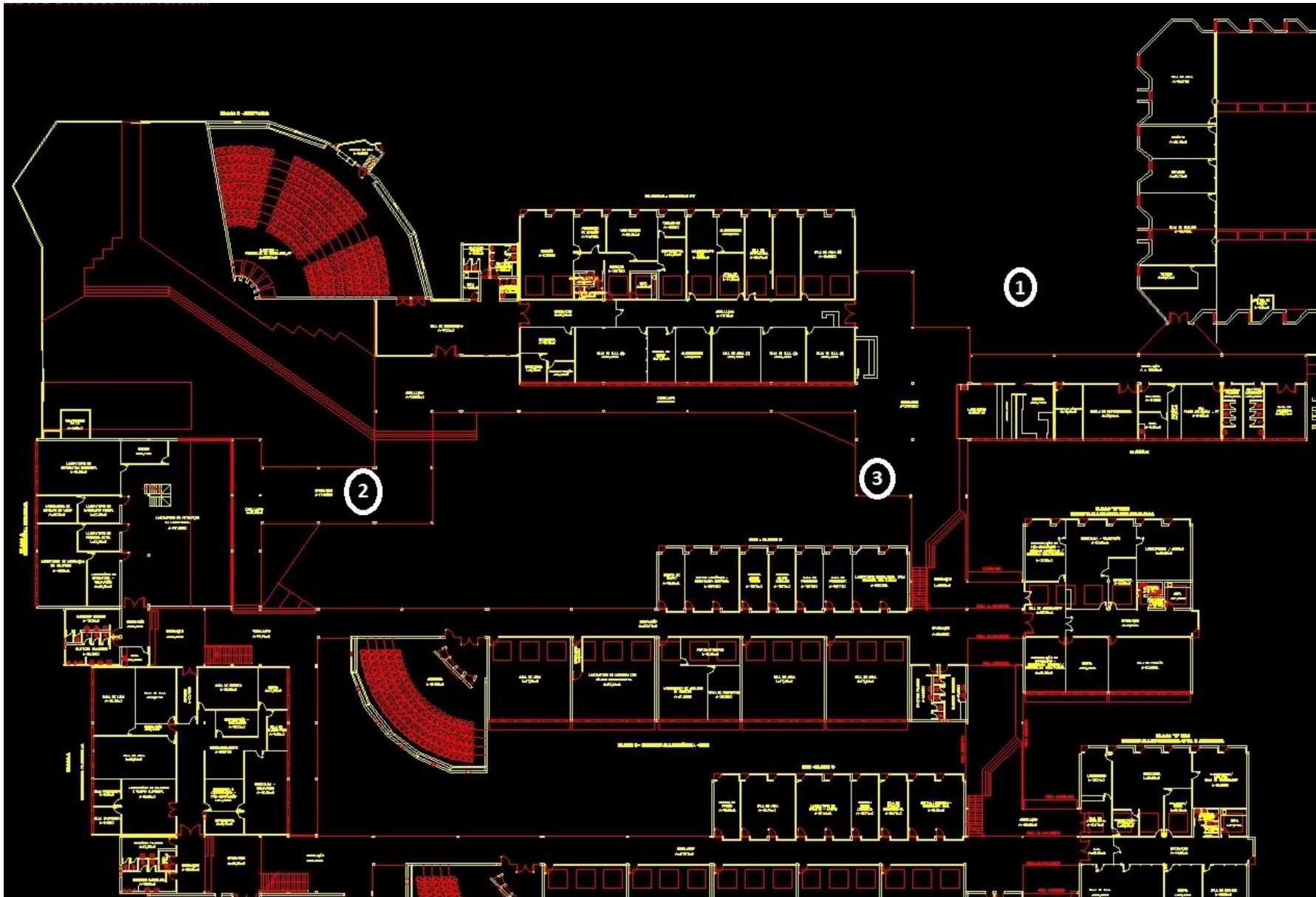
Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

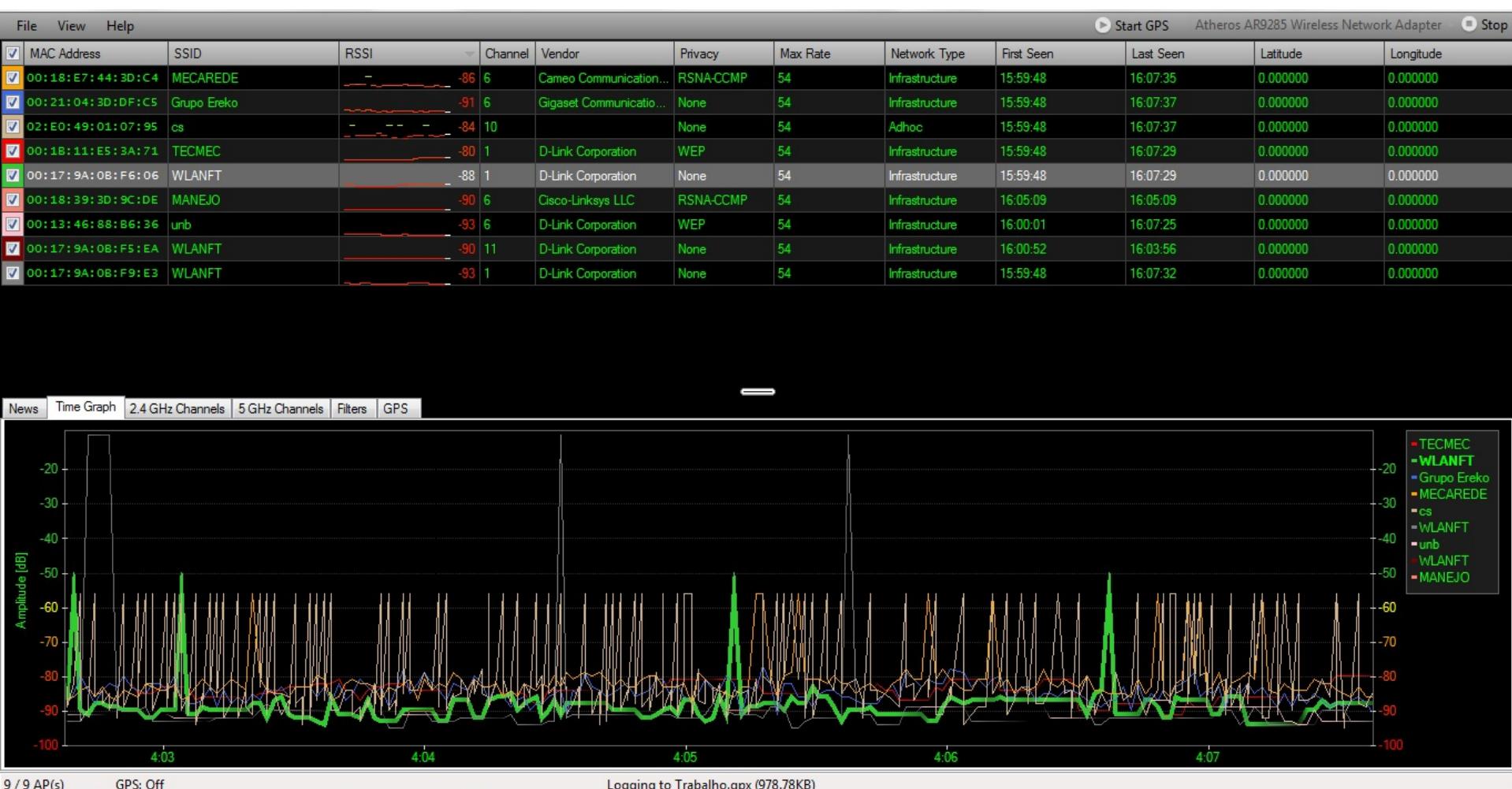
MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:18:11:E5:3A:71	TECMEC	-87	1	D-Link Corporation	WEP	54	Infrastructure	15:59:48	16:05:48	0.000000	0.000000
00:17:9A:0B:F6:06	WLANFT	-91	1	D-Link Corporation	None	54	Infrastructure	15:59:48	16:05:47	0.000000	0.000000
00:21:04:3D:DF:C5	Grupo Ereko	-83	6	Gigaset Communicatio...	None	54	Infrastructure	15:59:48	16:05:53	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-81	6	Cameo Communication...	RSNA-CCMP	54	Infrastructure	15:59:48	16:05:53	0.000000	0.000000
02:E0:49:01:07:95	cs	-83	10		None	54	Adhoc	15:59:48	16:05:53	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-89	1	D-Link Corporation	None	54	Infrastructure	15:59:48	16:05:50	0.000000	0.000000
00:13:46:88:B6:36	unb	-89	6	D-Link Corporation	WEP	54	Infrastructure	16:00:01	16:05:53	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-90	11	D-Link Corporation	None	54	Infrastructure	16:00:52	16:03:56	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-90	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:05:09	16:05:09	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

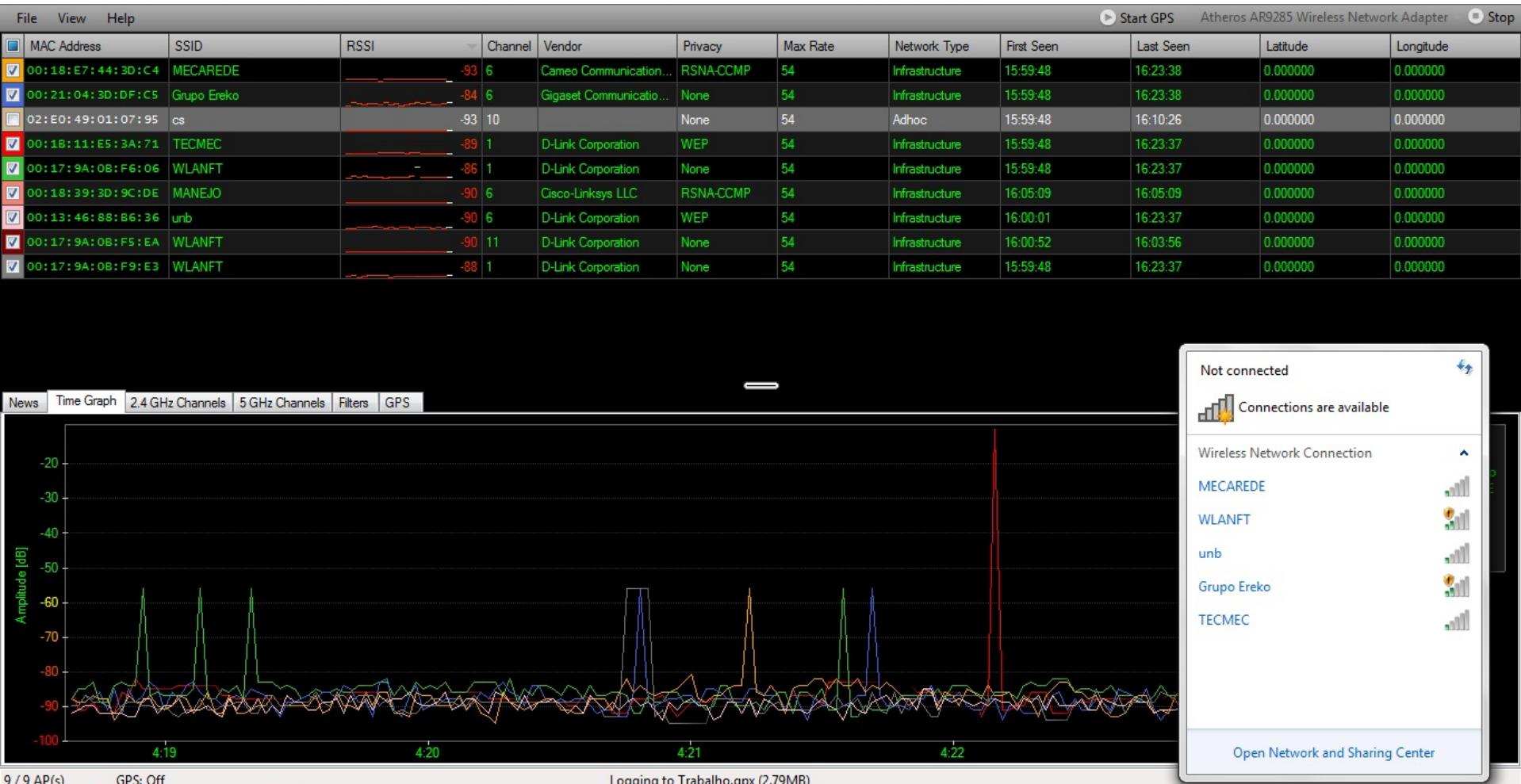
Amplitude [dB]

9 / 9 AP(s) GPS: Off Logging to Trabalho.gpx (757.18KB)

Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT

inSSIDer 2.0

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:17:9A:0B:F6:06	WLANFT	-68	1	D-Link Corporation	None	54	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-71	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:11:50:5E:C5:EF	SHP Wireless AP	-87	1	Belkin Corporation	WEP	54	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-86	1	D-Link Corporation	None	54	Infrastructure	16:34:34	16:39:59	0.000000	0.000000
00:18:11:E5:3A:71	TECMEC	-85	1	D-Link Corporation	WEP	54	Infrastructure	16:34:33	16:39:59	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-86	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:12:0E:8B:F0:C4	Obsis	-88	1	AboCom	WPA-TKIP	54	Infrastructure	16:34:33	16:40:01	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-85	11	D-Link Corporation	None	54	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:25:9C:FA:82:99	CATRON	-84	1	Cisco-Linksys, LLC	WEP	54	Infrastructure	16:34:33	16:40:04	0.000000	0.000000
00:23:69:D1:28:85	Optical Lab	-92	11	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:34:49	16:39:56	0.000000	0.000000
00:18:F8:C8:40:3E	wifi-ene	-91	11	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:34:58	16:39:44	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-92	6	Cameo Communicatio...	RSNA-CCMP	54	Infrastructure	16:34:36	16:39:59	0.000000	0.000000
00:21:91:BF:AC:B5	wlan-FT	-94	11	D-Link Corporation	None	54	Infrastructure	16:34:55	16:40:04	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-Unb	-94	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:34:33	16:40:02	0.000000	0.000000
00:24:01:FD:C9:64	LABREDES-POS	-90	6 + 10	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:35:36	16:40:04	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-10	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:35:48	16:39:52	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

20 / 20 AP(s) GPS: Off Logging to Trabalho2.gpx (1.70MB)

http://www.gli... 21.jpg - Paint pbestudoszica... New Text Doc... 16:40 19-2

Site Survey WLAN FT



Site Survey WLAN FT

inSSIDer 2.0

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Start

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:17:9A:0B:F6:06	WLANFT	-56	1	D-Link Corporation	None	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-72	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:11:50:5E:C5:EF	SHP Wireless AP	-82	1	Belkin Corporation	WEP	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-90	1	D-Link Corporation	None	54	Infrastructure	16:34:34	16:40:52	0.000000	0.000000
00:18:11:E5:3A:71	TECMEC	-81	1	D-Link Corporation	WEP	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-81	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:12:0E:8B:F0:C4	Obsis	-86	1	AboCom	WPA-TKIP	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-80	11	D-Link Corporation	None	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:25:9C:FA:82:99	CATRON	-87	1	Cisco-Linksys, LLC	WEP	54	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:23:69:D1:28:85	Optical Lab	-93	11	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:34:49	16:40:20	0.000000	0.000000
00:18:F8:C8:40:3E	wifi-ene	-92	11	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:34:58	16:40:45	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-94	6	Cameo Communicatio...	RSNA-CCMP	54	Infrastructure	16:34:36	16:40:47	0.000000	0.000000
00:21:91:BF:AC:B5	wlan-FT	-91	11	D-Link Corporation	None	54	Infrastructure	16:34:55	16:40:51	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-UnB	-92	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:34:33	16:40:52	0.000000	0.000000
00:24:01:FD:C9:64	LABREDES-POS	-90	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:35:36	16:40:41	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-10	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:35:48	16:39:52	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

4:36 4:37 4:38 4:39 4:40

20 / 20 AP(s) GPS: Off Logging: Off

http://www.glo... trabalho 2.2.jpg - Paint pbestudoszica... New Text Doc... 16:42 19-2

Not connected Connections are available

Wireless Network Connection

- gabler
- WLANFT
- MECAREDE
- TECMEC
- SHP Wireless AP
- CATRON
- MANEJO
- Obsis

Open Network and Sharing Center

Site Survey WLAN FT

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File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:21:04:3D:DF:C5	Grupo Ereko	-60	6	Gigaset Communicatio...	None	54	Infrastructure	16:25:49	16:31:43	0.000000	0.000000
00:18:11:E5:3A:71	TECMEC	-78	1	D-Link Corporation	WEP	54	Infrastructure	16:25:49	16:31:43	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-76	6	Cameo Communication...	RSNA-CCMP	54	Infrastructure	16:25:49	16:31:43	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-81	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:31:43	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-UnB	-84	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:31:43	0.000000	0.000000
00:17:9A:0B:F6:06	WLANFT	-81	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:31:34	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-88	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:31:41	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-85	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:31:43	0.000000	0.000000
00:13:46:88:B6:36	unb	-86	6	D-Link Corporation	WEP	54	Infrastructure	16:25:50	16:31:36	0.000000	0.000000
00:26:5A:61:D6:34	rec	-91	6 + 2	D-Link Corporation	WPA-CCMP	150 (N)	Infrastructure	16:25:54	16:31:43	0.000000	0.000000
00:17:9A:0B:F6:12	ENE	-95	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:29:41	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-87	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:25:50	16:31:43	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-90	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:27:04	16:29:56	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

The spectrum graph displays signal amplitude in dB over time (1 to 14 seconds). Several access points are tracked: TECMEC (red), WLANFT (orange), NETSKULL (blue), gabler (green), rec (purple), and Grupo Ereko (yellow). The graph shows periodic signal transmissions from each AP.

13 / 13 AP(s) GPS: Off Logging to Trabalho.gpx (4.59MB)

Site Survey WLAN FT

inSSIDer 2.0

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:21:04:3D:DF:C5	Grupo Ereko	-65	6	Gigaset Communicatio...	None	54	Infrastructure	16:25:49	16:31:05	0.000000	0.000000
00:18:11:E5:3A:71	TECMEC	-77	1	D-Link Corporation	WEP	54	Infrastructure	16:25:49	16:31:05	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-72	6	Cameo Communication...	RSNA-CCMP	54	Infrastructure	16:25:49	16:31:05	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-71	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:31:05	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-UnB	-90	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:31:05	0.000000	0.000000
00:17:9A:0B:F6:06	WLANFT	-85	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:31:05	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-90	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:30:58	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-85	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:31:05	0.000000	0.000000
00:13:46:88:B6:36	unb	-87	6	D-Link Corporation	WEP	54	Infrastructure	16:25:50	16:31:04	0.000000	0.000000
00:26:5A:61:D6:34	rec	-92	6 + 2	D-Link Corporation	WPA-CCMP	150 (N)	Infrastructure	16:25:54	16:31:05	0.000000	0.000000
00:17:9A:0B:F6:12	ENE	-95	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:29:41	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-87	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:25:50	16:31:05	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-90	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:27:04	16:29:56	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

Legend:

- TECMEC
- Grupo Ereko
- MECAREDE
- WLANFT
- NETSKULL-UnB
- gabler
- MANEJO
- unb
- WLANFT
- ENE
- rec
- wageva_wifi

13 / 13 AP(s) GPS: Off Logging to Trabalho.gpx (4.42MB) Not connected - Connections are available 16:31 19-3

Site Survey WLAN FT

inSSIDer 2.0

File View Help Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:21:04:3D:DF:C5	Grupo Ereko	-62	6	Gigaset Communicatio...	None	54	Infrastructure	16:25:49	16:32:14	0.000000	0.000000
00:18:11:E5:3A:71	TECMEC	-72	1	D-Link Corporation	WEP	54	Infrastructure	16:25:49	16:32:14	0.000000	0.000000
00:18:E7:44:3D:C4	MECAREDE	-71	6	Cameo Communication...	RSNA-CCMP	54	Infrastructure	16:25:49	16:32:14	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-72	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-UnB	-86	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:17:9A:0B:F6:06	WLANFT	-81	1	D-Link Corporation	None	54	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-90	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-89	6 + 2	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:13:46:88:B6:36	unb	-90	6	D-Link Corporation	WEP	54	Infrastructure	16:25:50	16:32:14	0.000000	0.000000
00:26:5A:61:D6:34	rec	-92	6	D-Link Corporation	WPA-CCMP	150 (N)	Infrastructure	16:25:54	16:32:13	0.000000	0.000000
00:17:9A:0B:F6:12	ENE	-95	11	D-Link Corporation	None	54	Infrastructure	16:25:50	16:29:41	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-88	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:25:50	16:32:13	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-90	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:27:04	16:29:50	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

The spectrum graph displays signal amplitude in dB over time (1 to 13 seconds). Several networks are visible: WLANFT (multiple instances), MECAREDE, NETSKULL-UnB, gabler, unb, Grupo Ereko, and MANEJO. The graph shows the rise and fall of signal strength for each network as they transmit.

13 / 13 AP(s) GPS: Off Logging to Trabalho.gpx (4.75MB)

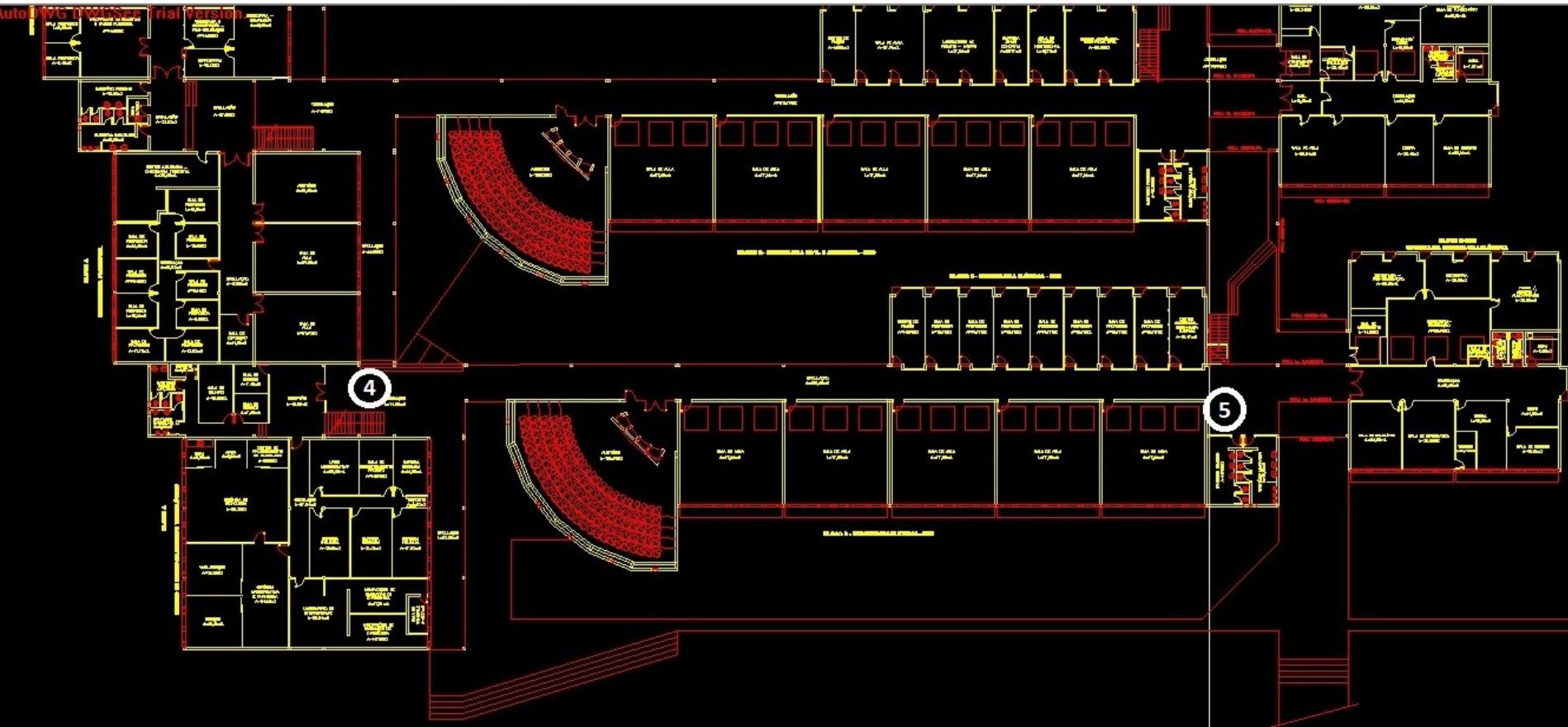
Not connected Connections are available

Wireless Network Connection

- MECAREDE
- TECMEC
- WLANFT
- Grupo Ereko
- NETSKULL-UnB
- gabler
- unb

Open Network and Sharing Center

Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT

inSSIDer 2.0

	MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
<input checked="" type="checkbox"/>	00:18:39:3D:9C:DE	MANEJO	-10	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:43:29	16:46:13	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0B:F5:E7	WLANFT	-79	1	D-Link Corporation	None	54	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0A:0B:0D	ENE	-79	11	D-Link Corporation	None	54	Infrastructure	16:43:30	16:47:52	0.000000	0.000000
<input checked="" type="checkbox"/>	00:E0:98:54:0E:DA	Caredes	-77	11	AboCom Systems, Inc.	WPA-TKIP	54	Infrastructure	16:43:30	16:47:52	0.000000	0.000000
<input checked="" type="checkbox"/>	00:26:5A:5B:3B:F2	gabler	-74	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0C:06:90	ENE	-74	11	D-Link Corporation	None	54	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:18:11:65:3A:71	TECMEC	-77	1	D-Link Corporation	WEP	54	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:21:91:8F:AC:B5	wlan-FT	-80	11	D-Link Corporation	None	54	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:24:01:FD:C9:64	LABREDES-POS	-78	6 + 10	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:11:50:5E:C5:EF	SHP Wireless AP	-80	1	Belkin Corporation	WEP	54	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0B:F9:E3	WLANFT	-81	1	D-Link Corporation	None	54	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:24:01:FD:C9:66	LABREDES	-56	1	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:43:29	16:47:52	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0B:F6:12	ENE	-81	11	D-Link Corporation	None	54	Infrastructure	16:43:54	16:47:52	0.000000	0.000000
<input checked="" type="checkbox"/>	00:18:F8:C8:40:3E	wifi-ene	-86	11	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:18:F8:6E:93:A5	NMI - FT	-56	1	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:43:29	16:47:57	0.000000	0.000000
<input checked="" type="checkbox"/>	00:23:69:D1:28:85	Optical Lab	-83	11	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:43:30	16:47:34	0.000000	0.000000
<input checked="" type="checkbox"/>	00:26:5A:61:C9:B4	NETSKULL-UnB	-86	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	74:EA:3A:BE:60:FO	AMZA	-87	1	TP-LINK Technologie...	RSNA-CCMP	54 (N)	Infrastructure	16:43:29	16:47:26	0.000000	0.000000
<input checked="" type="checkbox"/>	00:21:04:3D:DF:C5	Grupo Ereko	-87	6	Gigaset Communicatio...	None	54	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0B:F5:EA	WLANFT	-88	11	D-Link Corporation	None	54	Infrastructure	16:43:29	16:46:20	0.000000	0.000000
<input checked="" type="checkbox"/>	00:18:E7:44:3D:C4	MECAREDE	-89	6	Cameo Communicatio...	RSNA-CCMP	54	Infrastructure	16:43:29	16:43:29	0.000000	0.000000
<input checked="" type="checkbox"/>	00:17:9A:0B:F6:06	WLANFT	-90	1	D-Link Corporation	None	54	Infrastructure	16:43:29	16:46:16	0.000000	0.000000

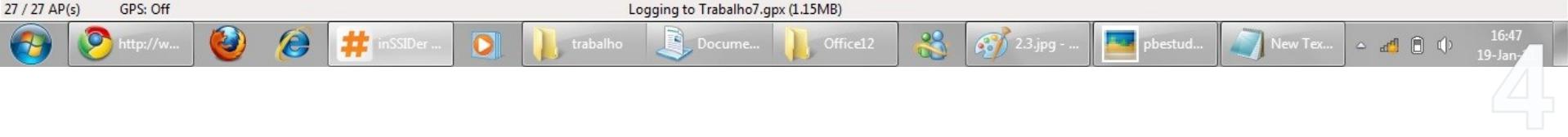
News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

4:43 4:44 4:45 4:46 4:47

Legend: SHP Wireless AP, CATRON, TECMEC, WLANFT, MANEJO, ...

27 / 27 AP(s) GPS: Off Logging to Trabalho7.gpx (1.15MB)



Site Survey WLAN FT



Site Survey WLAN FT

inSSIDer 2.0

File View Help Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:17:9A:0B:F5:E7	WLANFT	-76	1	D-Link Corporation	None	54	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:1D:7E:BA:74:CA	linksys	-90	1	Cisco-Linksys, LLC	RSNA-CCMP	54 (N)	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:24:01:FD:C9:66	LABREDES	-91	1 + 5	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:18:F8:6E:93:A5	NMI - FT	-78	1	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:24:01:FD:C9:64	LABREDES-POS	-80	6 + 10	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:13:46:88:B6:36	unb	-91	6	D-Link Corporation	WEP	54	Infrastructure	16:51:20	16:51:49	0.000000	0.000000
00:18:F8:C8:40:3E	wifi-ene	-83	11	Cisco-Linksys LLC	WPA-TKIP	54	Infrastructure	16:51:20	16:51:33	0.000000	0.000000
00:17:9A:0C:06:90	ENE	-74	11	D-Link Corporation	None	54	Infrastructure	16:51:20	16:51:46	0.000000	0.000000
00:17:9A:0B:F6:12	ENE	-82	11	D-Link Corporation	None	54	Infrastructure	16:51:20	16:51:43	0.000000	0.000000
00:21:91:8F:AC:B5	wlan-FT	-78	11	D-Link Corporation	None	54	Infrastructure	16:51:20	16:51:48	0.000000	0.000000
00:23:69:D1:28:85	Optical Lab	-84	11	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:51:20	16:51:20	0.000000	0.000000
00:E0:98:54:0E:DA	Caredes	-79	11	AboCom Systems, Inc.	WPA-TKIP	54	Infrastructure	16:51:20	16:51:48	0.000000	0.000000
00:25:9C:FA:32:B9	wageva_wifi	-44	1	Cisco-Linksys, LLC	RSNA-CCMP	54	Infrastructure	16:51:21	16:51:31	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-Unb	-92	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:51:21	16:51:31	0.000000	0.000000
00:26:5A:5B:3B:F2	gabler	-95	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:51:24	16:51:30	0.000000	0.000000
00:17:9A:0A:0B:0D	ENE	-76	11	D-Link Corporation	None	54	Infrastructure	16:51:25	16:51:40	0.000000	0.000000
00:17:9A:0B:F5:EA	WLANFT	-90	11	D-Link Corporation	None	54	Infrastructure	16:51:25	16:51:40	0.000000	0.000000
00:17:9A:0B:F6:06	WLANFT	-56	1	D-Link Corporation	None	54	Infrastructure	16:51:31	16:51:40	0.000000	0.000000
00:18:39:3D:9C:DE	MANEJO	-93	6	Cisco-Linksys LLC	RSNA-CCMP	54	Infrastructure	16:51:31	16:51:33	0.000000	0.000000
00:25:9C:FA:82:99	CATRON	-88	1	Cisco-Linksys, LLC	WEP	54	Infrastructure	16:51:35	16:51:38	0.000000	0.000000
74:EA:3A:BE:60:F0	AMZA	-85	1	TP-LINK Technologies...	RSNA-CCMP	54 (N)	Infrastructure	16:51:38	16:51:40	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

1 2 3 4 5 6 7 8 9 10 11 12 13

GPS: Off Logging: Off

21 / 21 AP(s) Open Network and Sharing Center

http://w... inSSIDer ... trabalho Docume... Office12 7.3.jpg - ... pbcivilen... New Tex... 16:51 19-Jan-14

Site Survey WLAN FT

inSSIDer 2.0

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First Seen	Last Seen	Latitude	Longitude
00:24:01:FD:C9:64	LABREDES-POS	-10	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:53:38	16:53:38	0.000000	0.000000
00:17:9A:0B:F6:12	ENE	-58	11	D-Link Corporation	None	54	Infrastructure	16:53:38	16:54:56	0.000000	0.000000
00:17:9A:0A:0B:0D	ENE	-75	11	D-Link Corporation	None	54	Infrastructure	16:53:38	16:54:56	0.000000	0.000000
00:17:9A:0C:06:90	ENE	-68	11	D-Link Corporation	None	54	Infrastructure	16:53:38	16:53:38	0.000000	0.000000
36:A9:05:0E:93:A0	hpsetup	-74	6		None	54	Adhoc	16:53:40	16:54:56	0.000000	0.000000
00:17:9A:0B:F9:E3	WLANFT	-84	1	D-Link Corporation	None	54	Infrastructure	16:53:41	16:54:56	0.000000	0.000000
00:1D:7E:BA:74:CA	linksys	-87	1	Cisco-Linksys, LLC	RSNA-CCMP	54 (N)	Infrastructure	16:53:38	16:53:38	0.000000	0.000000
00:26:5A:61:C9:B4	NETSKULL-UnB	-89	6	D-Link Corporation	RSNA-CCMP	150 (N)	Infrastructure	16:53:38	16:53:38	0.000000	0.000000
00:17:9A:0B:F5:E7	WLANFT	-94	1	D-Link Corporation	None	54	Infrastructure	16:53:38	16:54:56	0.000000	0.000000
00:26:5A:61:D6:34	rec	-89	6 + 2	D-Link Corporation	WPA-CCMP	150 (N)	Infrastructure	16:53:40	16:54:56	0.000000	0.000000
00:13:46:88:86:36	unb	-91	6	D-Link Corporation	WEP	54	Infrastructure	16:53:41	16:54:29	0.000000	0.000000

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

11 / 11 AP(s) GPS: Off Logging: Off

http://www... trabalho Documents 74.jpg - Pa... pbcivilene.j... New Text D... 16:54 19-J-

Site Survey WLAN FT



Site Survey WLAN FT



Site Survey WLAN FT

inSSIDer 2.0

File View Help

Start GPS Atheros AR9285 Wireless Network Adapter Stop

MAC Address	SSID	RSSI	Channel	Vendor	Privacy	Max Rate	Network Type	First S
00:24:01:FD:C9:64	LABREDE...	-10	6	D-Link Corpo...	RSNA-CCMP	150 (N)	Infrastructure	16:53
00:17:9A:0B:F6:12	ENE	-56	11	D-Link Corpo...	None	54	Infrastructure	16:53
00:17:9A:0C:06:90	ENE	-68	11	D-Link Corpo...	None	54	Infrastructure	16:53
00:17:9A:0A:0B:0D	ENE	-79	11	D-Link Corpo...	None	54	Infrastructure	16:53
36:A9:05:0E:93:A0	hpsetup	-78	6	None	None	54	Adhoc	16:53
00:17:9A:0B:F5:E7	WLANFT	-89	1	D-Link Corpo...	None	54	Infrastructure	16:53
00:17:9A:0B:F9:E3	WLANFT	-90	1	D-Link Corpo...	None	54	Infrastructure	16:53
00:1D:7E:BA:74:CA	linksys	-87	1	Cisco-Linksys...	RSNA-CCMP	54 (N)	Infrastructure	16:53
00:26:5A:61:C9:B4	NETSKUL...	-89	6	D-Link Corpo...	RSNA-CCMP	150 (N)	Infrastructure	16:53
00:26:5A:61:D6:34	rec	-91	6 + 2	D-Link Corpo...	WPA-CCMP	150 (N)	Infrastructure	16:53
74:EA:3A:BE:60:F0	AMZA	-93	1	TP-LINK Tec...	RSNA-CCMP	54 (N)	Infrastructure	16:57
00:13:46:88:86:36	unb	-94	6	D-Link Corpo...	WEP	54	Infrastructure	16:53

News Time Graph 2.4 GHz Channels 5 GHz Channels Filters GPS

Amplitude [dB]

5:01 5:02 5:03 5:04

Not connected

Connections are available

Wireless Network Connection

ENE

hpsetup

rec

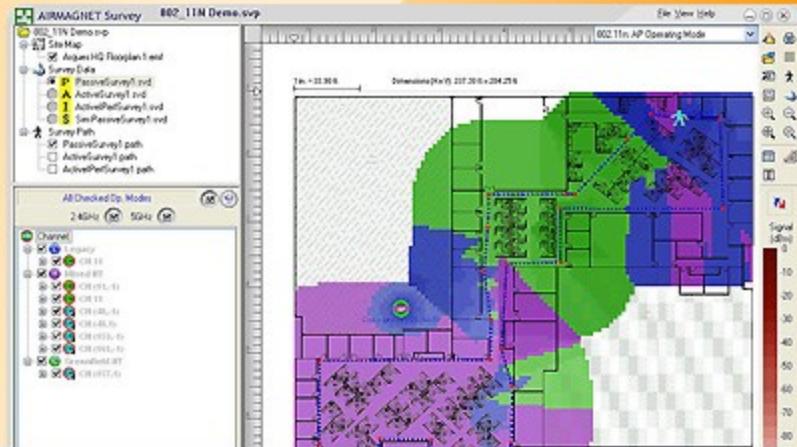
WLANFT

Open Network and Sharing Center

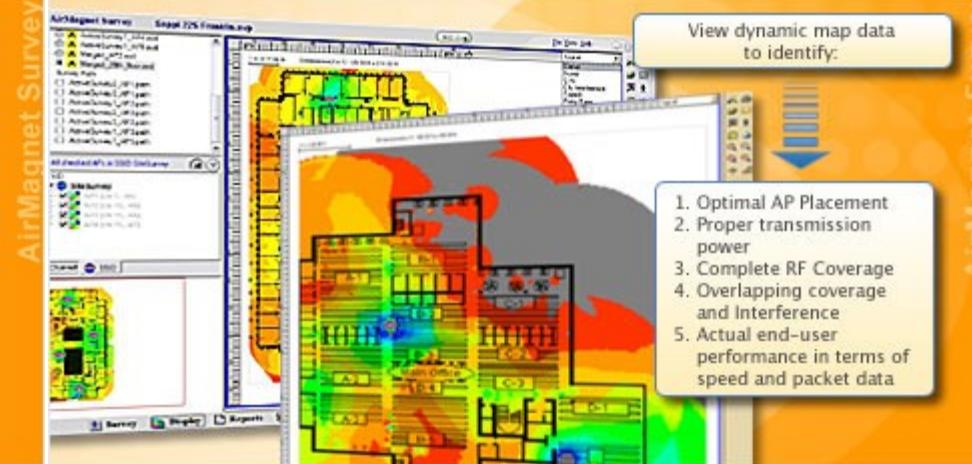
12 / 12 AP(s) GPS: Off Logging: Off

http://www.glob... Firefox Internet Explorer inSSIDer 2.0 plantabaixadetalh... New Text Docum... Untitled - Paint 17:05 19-J-5

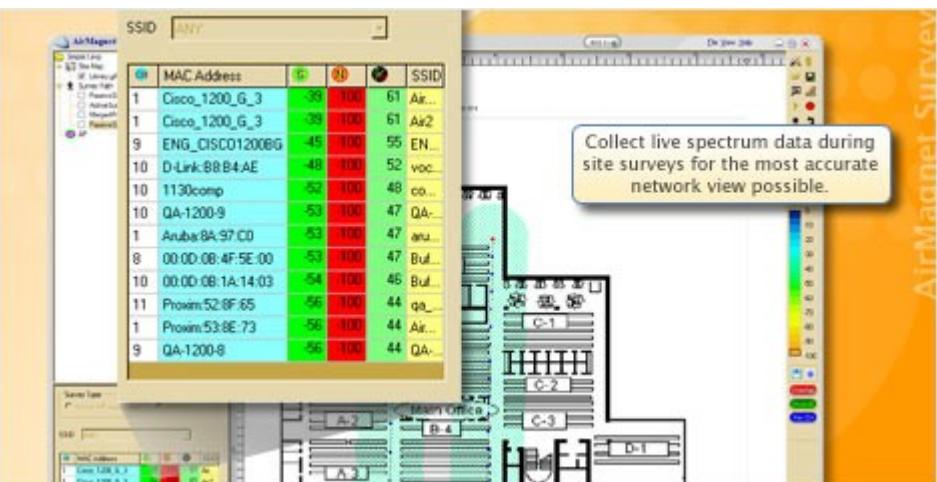
Site Survey



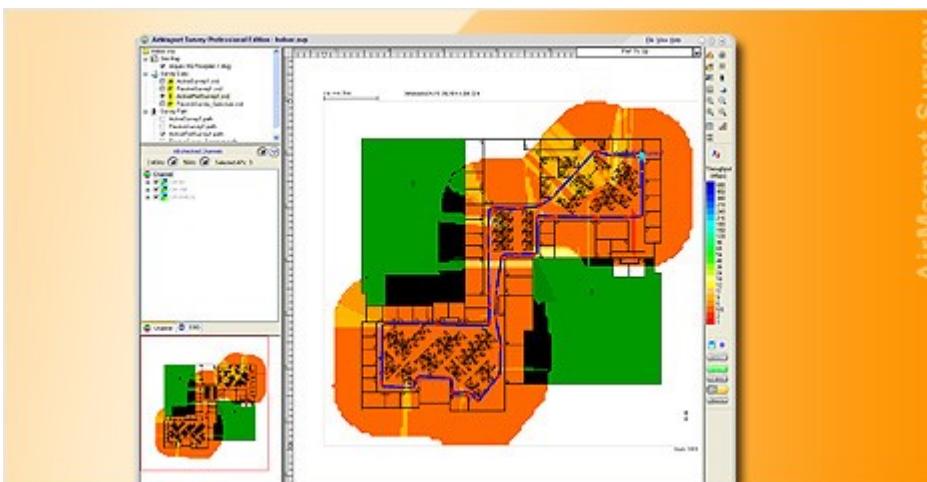
Mapa de Cobertura



Resultado do Survey

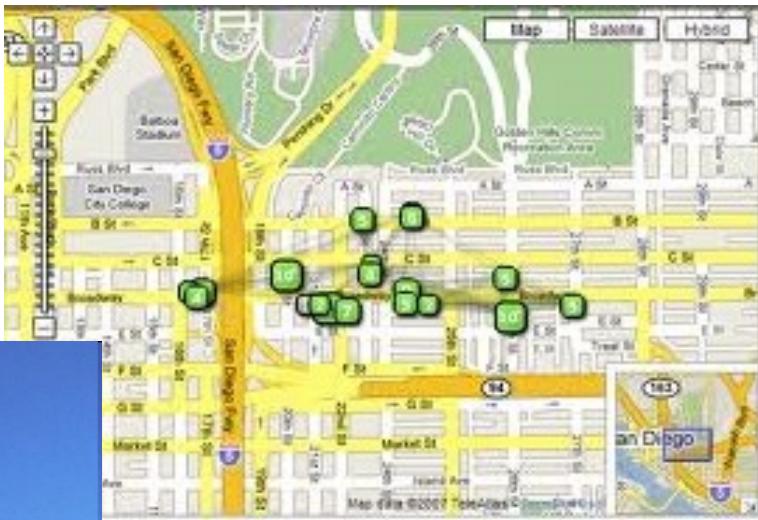


AP's detalhados



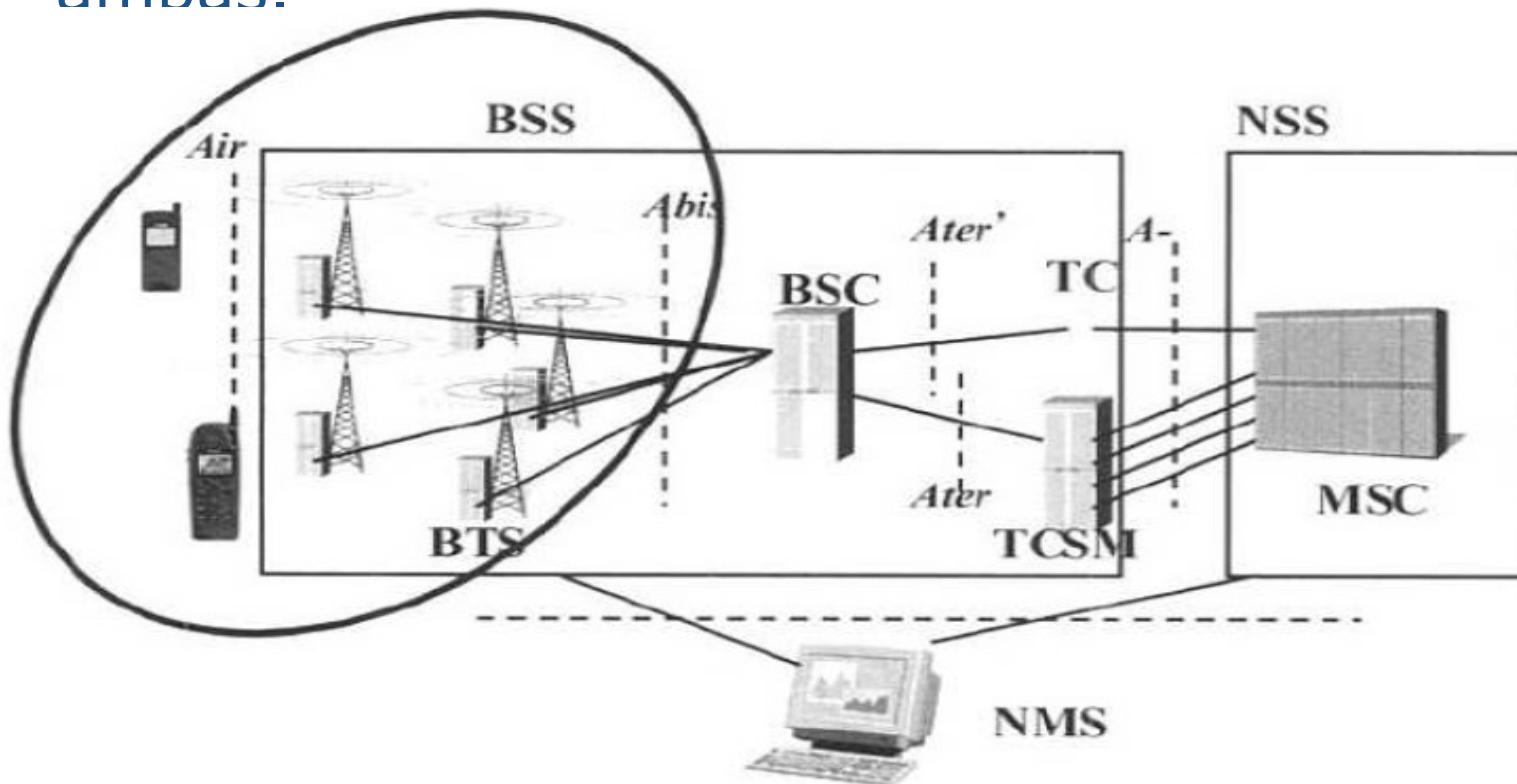
WLAN Throughput

Site Survey em Telefonia Celular GSM



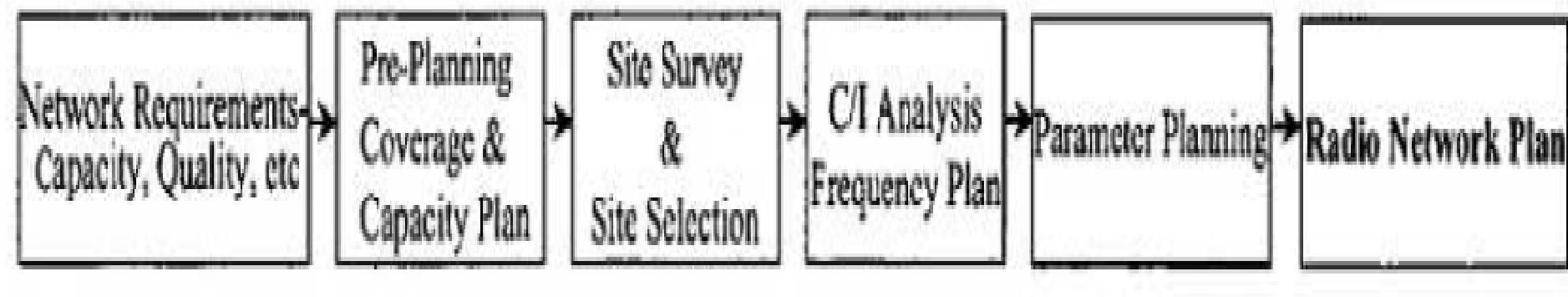
Planejamento da Rede de Rádio (Radio Network Planning)

- ❖ Rede de rádio é a parte da rede que inclui a ERB, a estação móvel e a interface entre ambas.



Processo de Planejamento da Rede de Acesso Rádio

A RN deve ser capaz de fornecer capacidade e cobertura suficientes.



Pré-planejamento

- ❖ Dimensionamento
- ❖ Planejamento inicial de Capacidade, Cobertura e Qualidade
- ❖ Objetivo: Maximizar a cobertura e minimizar os custos
- ❖ Site Survey e Site Selection

Planejamento detalhado da RAN

❖ Cálculos de Potência Necessária

Sensitividade e ganho do MS e BTS, margem de desvanecimento, perdas de cabos e conectores

❖ Frequency Hopping

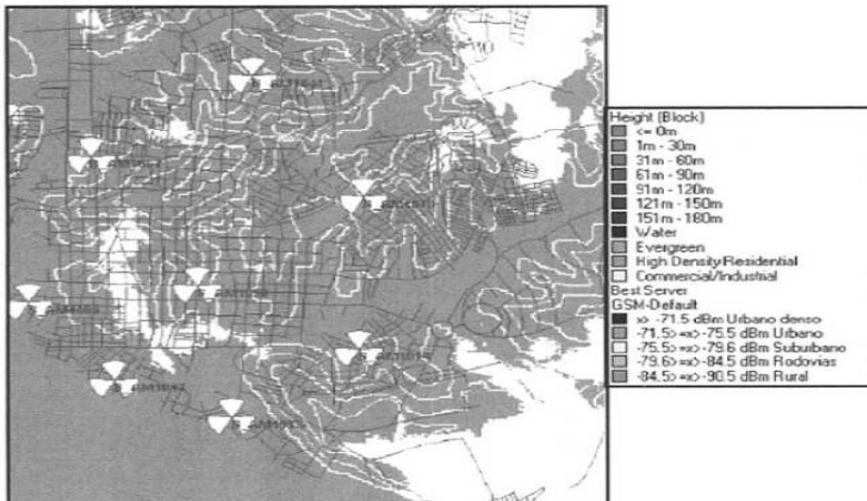
Aumenta a necessidade de potência

❖ Equipment Enhancements

Receiver diversity, LNA, Power boosters

❖ Cobertura de Rede e de Célula

(Modelos de Propagação, Planned Coverage Area, Probabilidade de Localização)



Planejamento detalhado da RAN

❖ Planejamento de Capacidade

Estimativas de tráfego, altura média de antena, uso e reuso de frequências

❖ Planejamento de frequência e eficiência espectral

❖ Controle de Potência

❖ Handover

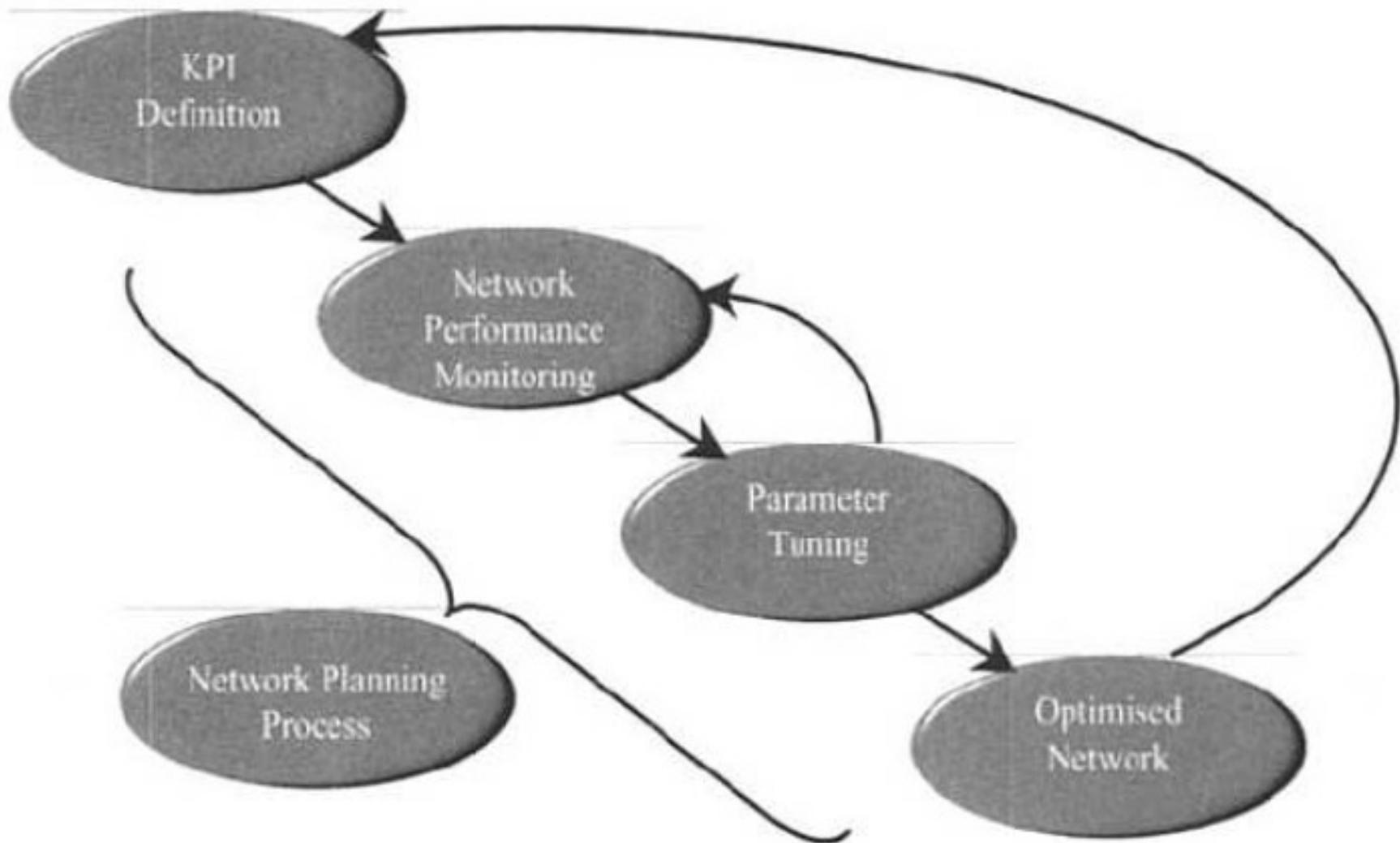
Influencia na potência das antenas

❖ Transmissão descontínua

❖ Planejamento de Parâmetros

Sinalização, recursos de rádio e gerenciamento de mobilidade, células vizinhas

Otimização da Rede



KPI – Key Performance Indicators

Parâmetros em qualidade de voz

❖ BER (bit error rate)

Baseado na medição do sinal recebido antes do processo de decodificação
Correlacionamento com a FER depende da codificação de canal e FH

❖ FER (frame error rate)

Indica a taxa de erro do sinal recebido após o processo de decodificação
Mais utilizado para indicar a qualidade de voz (variação uniforme)

❖ DCR (drop call rate)

Pode indicar limitações de capacidade, interferências, bloqueios, problemas de propagação, etc.

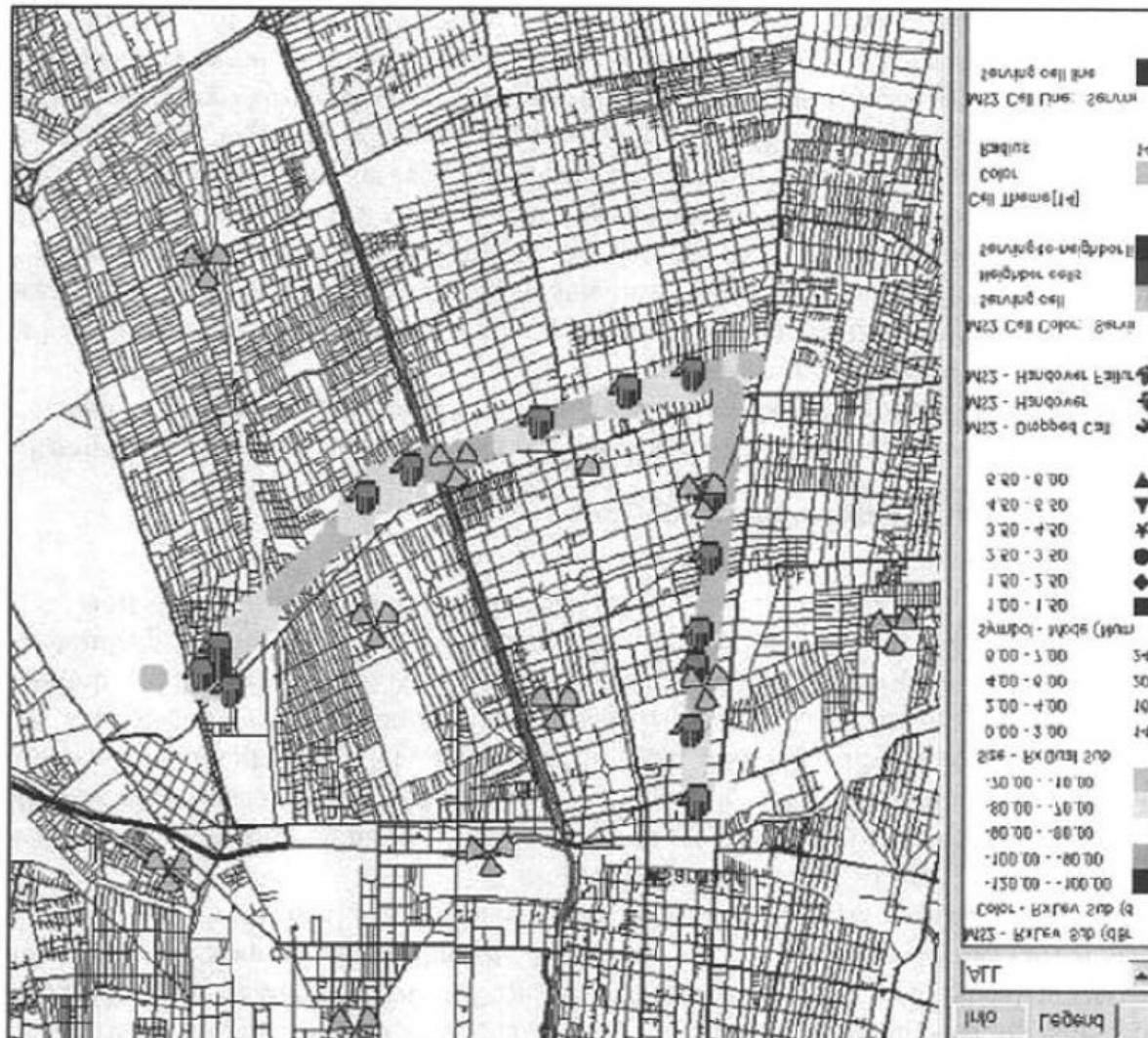
Indica a qualidade do gerenciamento de capacidade (CSR – call success rate)
Indica a qualidade do gerenciamento de mobilidade (HSR – handoff success rate)

Monitoração do Desempenho da Rede

- ❖ Drive Tests
- ❖ Sistemas de Gerenciamento de Rede

Otimização da Rede

Monitoração do Desempenho da Rede - Drive Testing

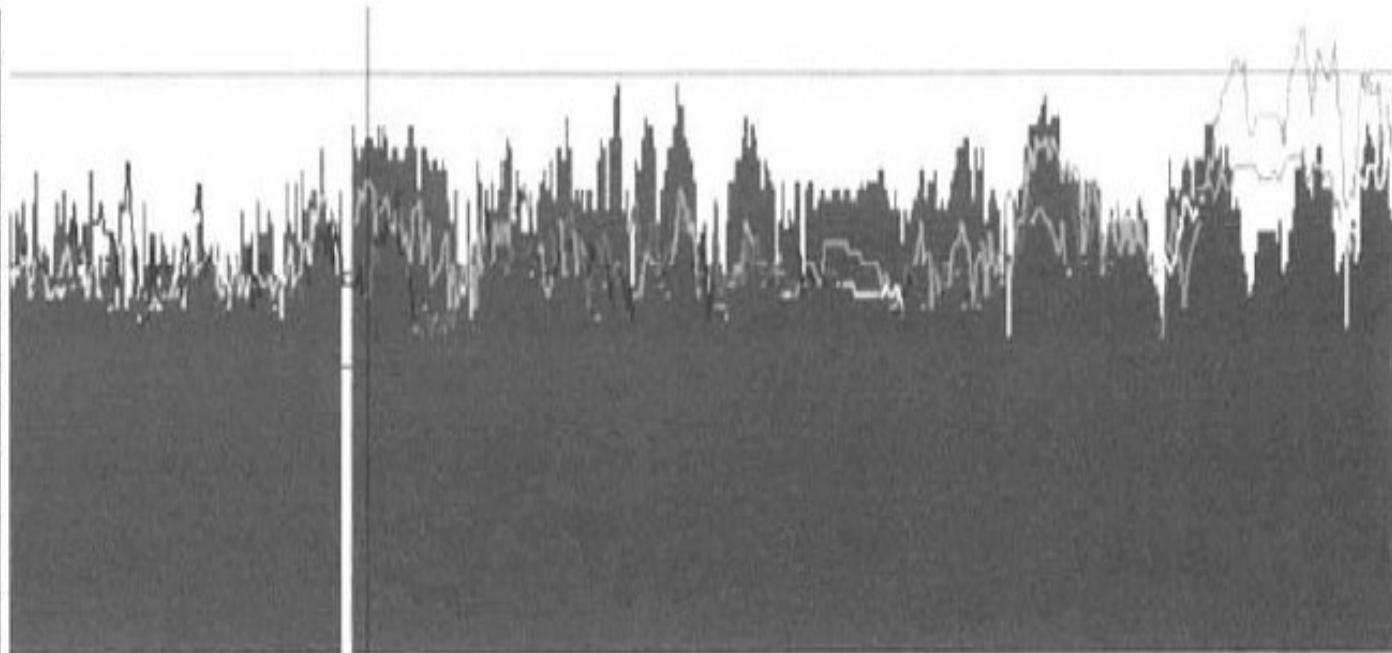


Fonte: [8]

Otimização da Rede

Monitoração do Desempenho da Rede - Drive Testing

Cellname	
CGI (MCC, MNC, LAC, Ci)	730 02 12001 12095
Cell GPRS Support	
Band	1900
BUCH ARFCN	597
UCH ARFCN	697
BSIC	25
Mode	Dedicated
Time slot	4
Channel type	TCH/F + FACCH/F and SACCH/F
Channel mode	Speech full rate or half rate version 1
Speech Codec	FR
Ciphering Algorithm	
Sub channel number	
Hopping channel	NO
Hopping frequencies	
Mobile Allocation Index Offset (MAIO)	
Hopping sequence number (HSN)	



I	E	Value	ARFCN	BSIC	MS
■	Ratelev Sub (dBm)	-59	697	25	MS2
■	Neighber Ratelev (d.	-69	695	27	MS2
■	Neighber Ratelev (d.	-72	596		MS2
I	E	Value	ARFCN	BSIC	MS
Time	05:52:24.95				
Cell Name			697	25	MS2
PCI	21		697	25	MS2
C/I Worst [0]	21.70		697		MS2

Monitoração do Desempenho da Rede - SGR

- Monitorar estatísticas da rede periodicamente
- Completamento de chamadas, handovers, tráfego, bloqueios
- Avaliar parâmetros de qualidade de serviço

Otimização da Rede

Exemplo: Stand Alone Dedicated Control Channel (fonte: [8])

SDCCH

SDCCH availability	/ava_4	81.30 %
Dynamic SDCCH allocation (TCH reconfigured to SDCCH):		
. Attempts	/c1154	0
SDCCH requests	/c1000	6617
. HO in.....	/c1006	0 (0.00 %)
. blocked	/tck_15 (block_5a)	33 (0.50 %)
. To FACCH call setup	/c1099	0 (0.00 %)
. LU	/c3019	4102 (61.99 %)
. MTC (incl. SMS)	/c3012	145 (2.19 %)
. MOC (incl. SMS,SS)	/c3013	343 (5.18 %)
. supplementary service request (S9)	/c3044	4 (0.06 %)
. IMSI detach (S7)	/c3033	114 (1.72 %)
. call re-establishment.....	/c3020	0 (0.00 %)
. emergency call	/c3021	255 (3.85 %)
. other (fails, ghosts)	/sd_1a	1625 (24.56 %)
SDCCH usage	/trf_7b	0.02 %
Average SDCCH seizure length	/trf_4	2.05 sec

SDCCH failures

SDCCH seizures	/trf_54	6584
SDCCH drop ratio	/sdr_1a	27.70 %
. SDCCH_RADIO_FAIL.....	/c1003	166 (2.52 %)
. SDCCH_A_IF_FAIL_CALL.....	/c1078	0 (0.00 %)
. SDCCH_ABIS_FAIL_CALL.....	/c1075	1658 (25.18 %)
. SDCCH_USER_ACT.....	/c1037	0 (0.00 %)
. SDCCH_BCSU_RESET.....	/c1038	0 (0.00 %)
. SDCCH_NETW_ACT.....	/c1039	0 (0.00 %)
. SDCCH_BTS_FAIL.....	/c1036	0 (0.00 %)
. SDCCH_LAPD_FAIL.....	/c1035	0 (0.00 %)
. SDCCH_RF_OLD_HO....(HO drop).....	/c1004	0 (0.00 %)
. SDCCH_ABIS_FAIL_OLD....(HO drop).....	/c1076	0 (0.00 %)
. SDCCH_A_IF_FAIL_OLD....(HO drop).....	/c1079	0 (0.00 %)

Avaliação da Performance da Rede

Comparação com os KPIs desejados:

- ❖ Cobertura
- ❖ Capacidade
- ❖ Qualidade

➔ Ajuste fino de parâmetros

Referências

- ❖ [1] BARDWELL, Joshua. *The Truth About 802.11 Signal and Noise Metrics - A Discussion Clarifying Often-Misused 802.11 WLAN Terminologies*
Disponível em http://n-cg.net/ngcpdf/WiFi_SignalValues.pdf.
- ❖ [2]http://www.wirelessnets.com/resources/tutorials/define_SNR_values.html
- ❖ [3]http://www.cisco.com/en/US/tech/tk722/tk809/technologies_q_and_a_item09186a00805e9a96.shtml
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- ❖ [7] <http://www.airmagnet.com/products/survey/>
- ❖ [8] Mishra, Ajay R. *Fundamentals of Cellular Network Planning and Optimisation: 2G/2.5G/3G... Evolution to 4G*, John Wiley & Sons, 2004.

Obrigado!

Perguntas?

