Self-Organizing Networks (SON)

Amer Alattar

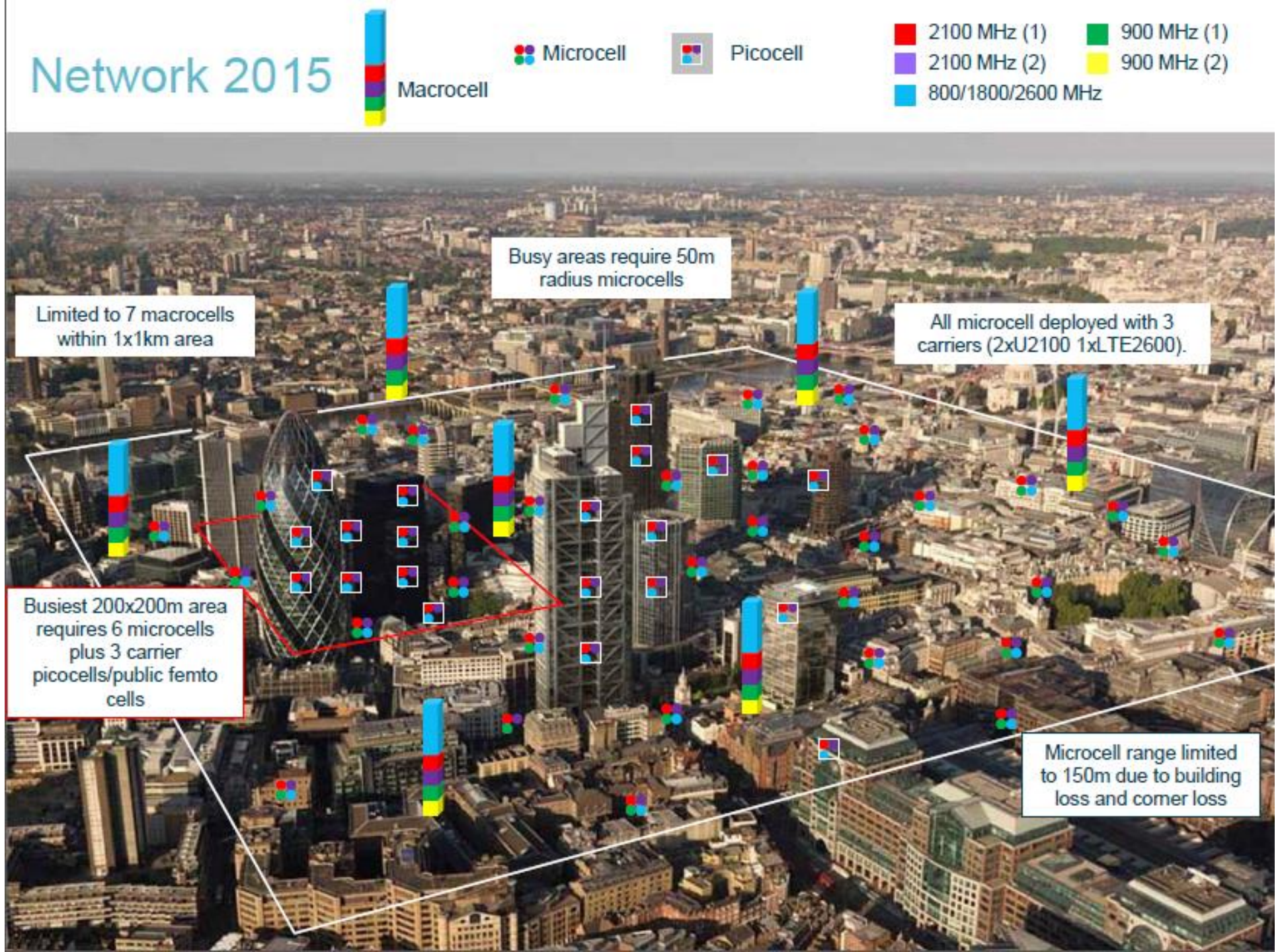
Technische Universität Berlin

Fraunhofer Heinrich Hertz Institute

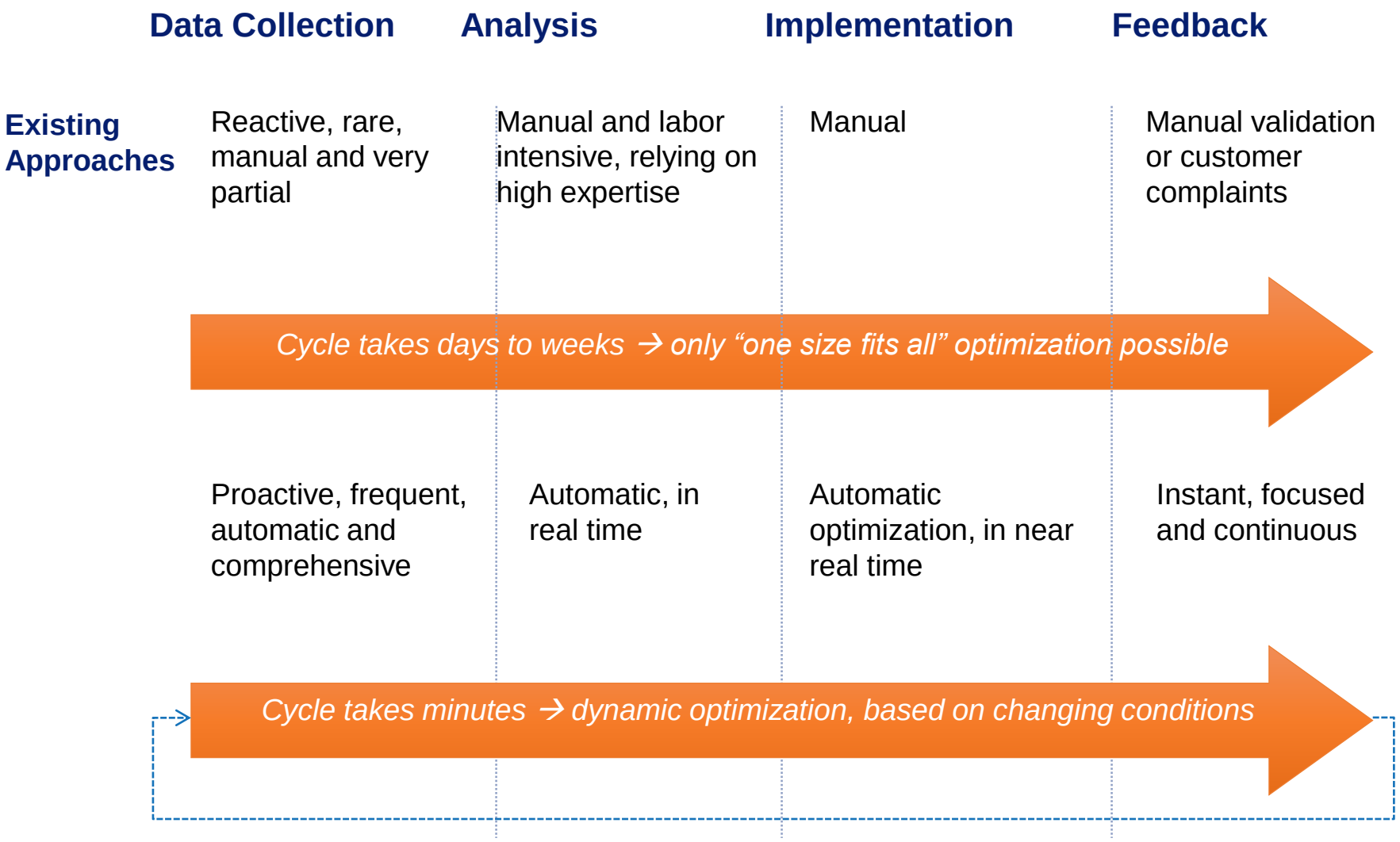
Outline

- Motivation
- Functionality
- SONs Main Modules
  - ANR – Automatic Neighbor Relation
  - APO – Automatic Parameter Organization
  - DLB – Dynamic Load Balancing
  - ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
  - DIM – Dynamic Interference Management
- The aim of the thesis
- Supervisor and Duration of the thesis

Network 2011

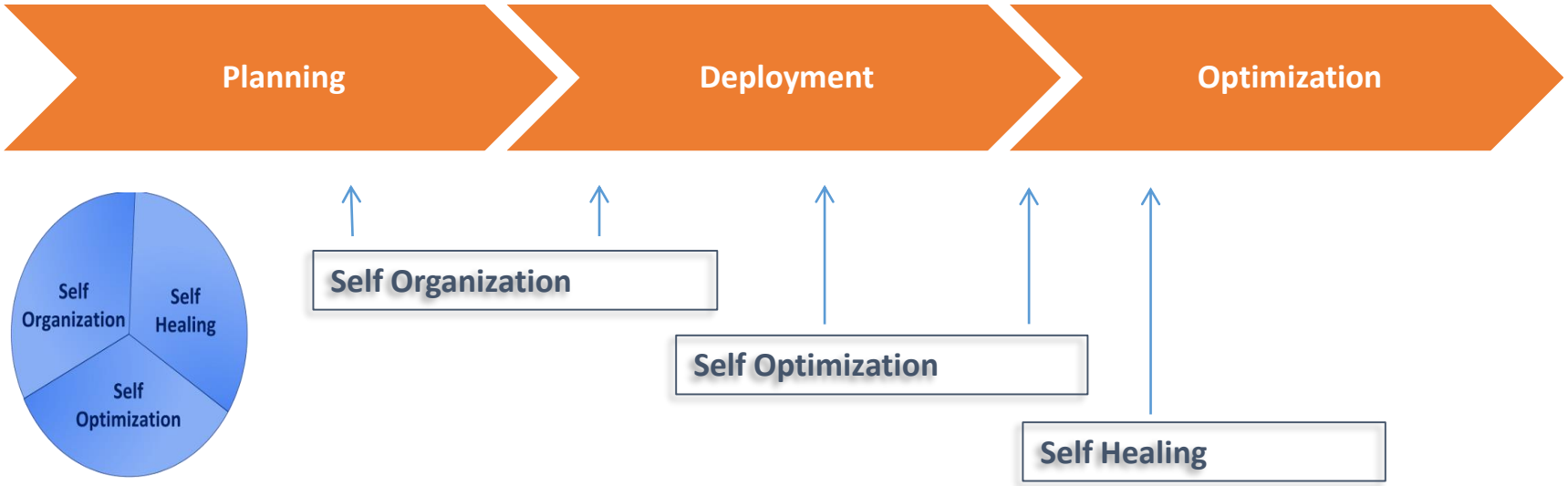

Network 2015
Macrocell
Microcell
Picocell
2100 MHz (1)
2100 MHz (2)
800/1800/2600 MHz
900 MHz (1)
900 MHz (2)
Busy areas require 50m radius microcells
Limited to 7 macrocells within 1x1km area
All microcell deployed with 3 carriers (2xU2100 1xLTE2600).
Busiest 200x200m area requires 6 microcells plus 3 carrier picocells/public femto cells
Microcell range limited to 150m due to building loss and corner loss

SON : The new way of optimization



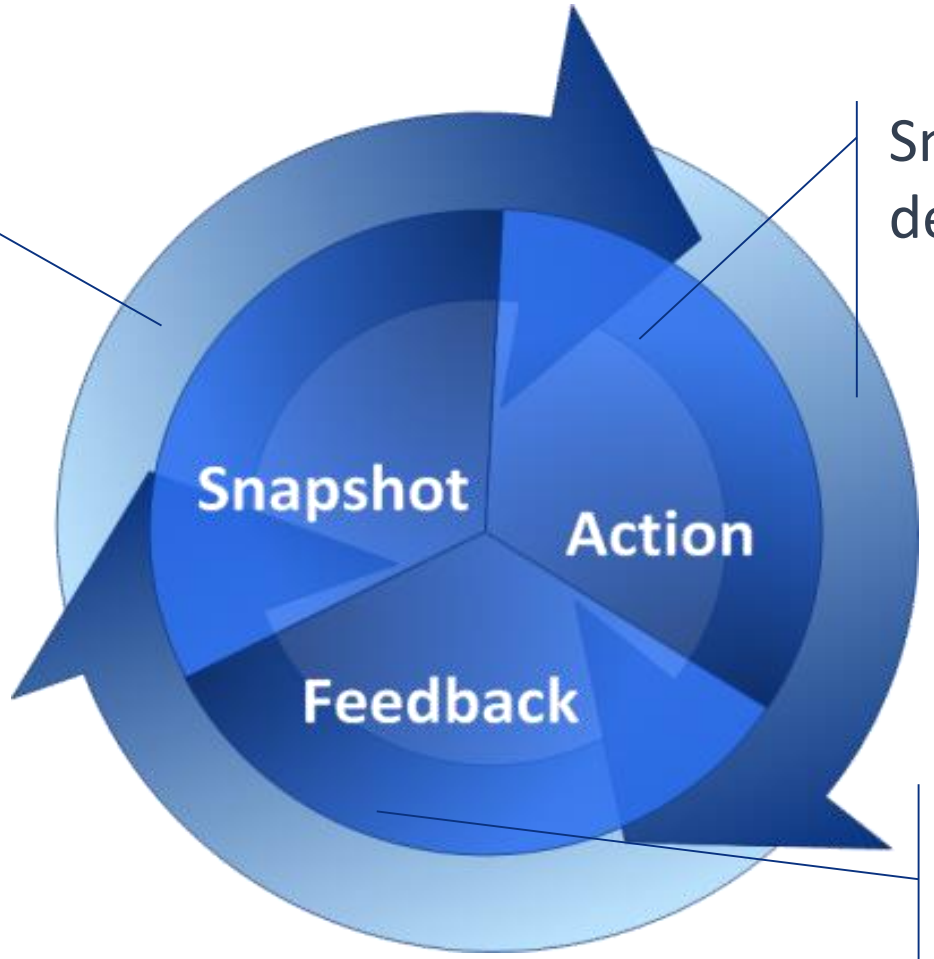
SON affects the entire life cycle RNPO

Radio Planning and Optimization life cycle



SON Cycle

Monitor and trigger



Smart algorithm to decide and action

Validation and Action

SONs Main Modules

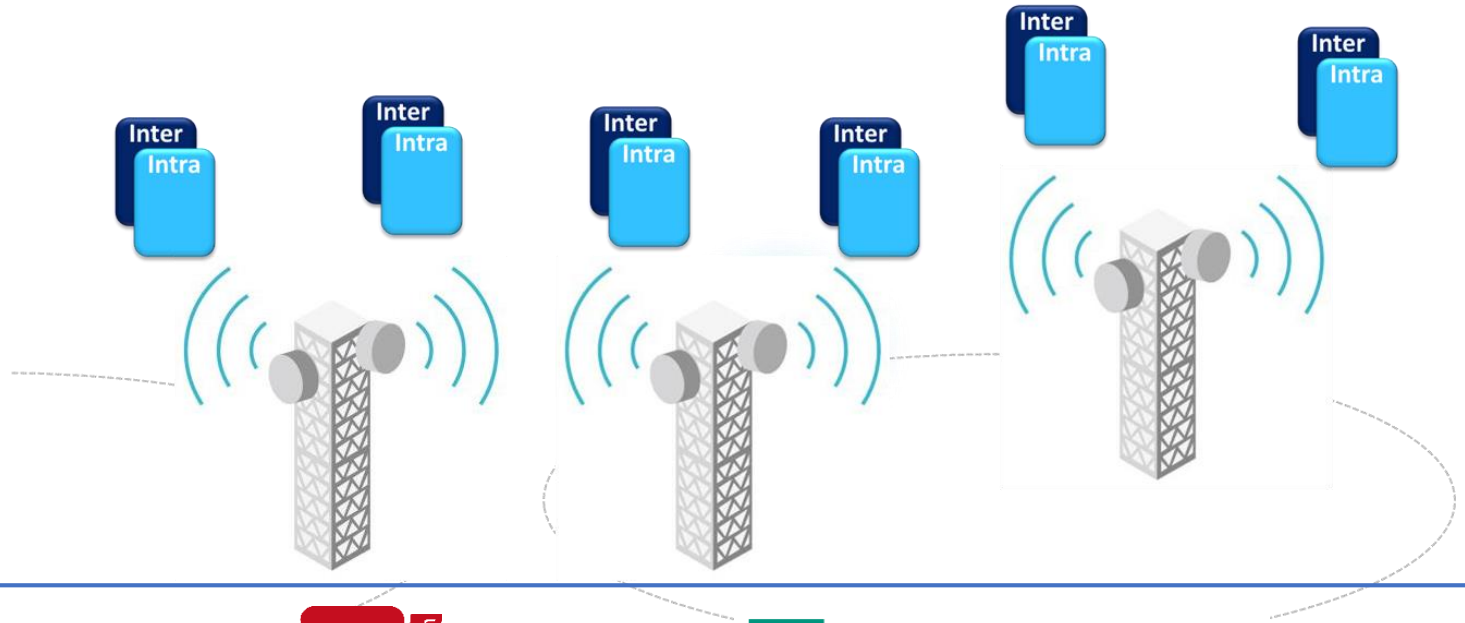
- ANR – Automatic Neighbor Relation
- APO – Automatic Parameter Organization
- DLB – Dynamic Load Balancing
- ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
- DIM – Dynamic Interference Management

SONs Main Modules

- **ANR – Automatic Neighbor Relation**
- APO – Automatic Parameter Organization
- DLB – Dynamic Load Balancing
- ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
- DIM – Dynamic Interference Management

The SON ANR Application

Builds and maintains an optimal intra carrier and inter carrier neighbor lists automatically and dynamically

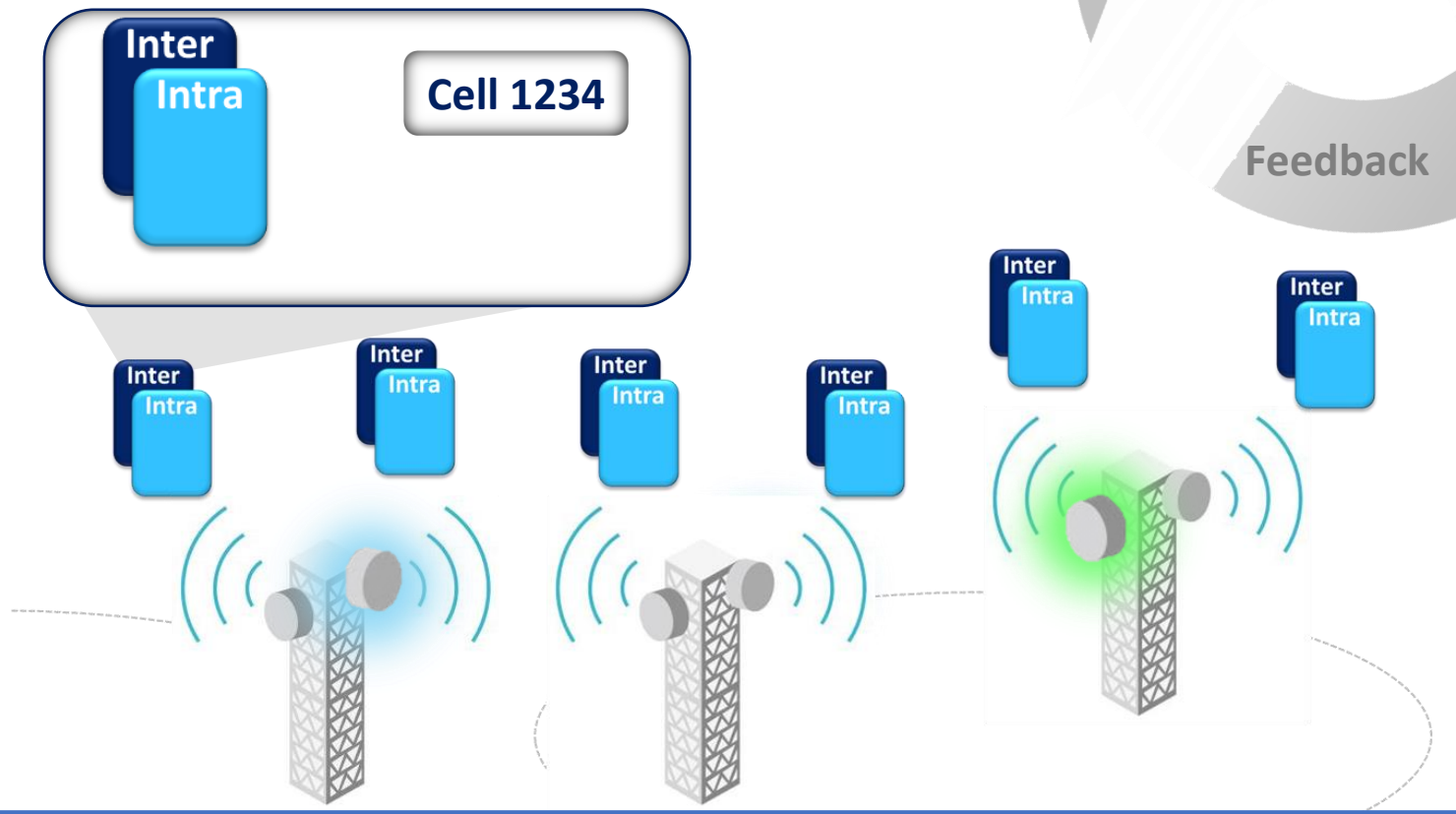


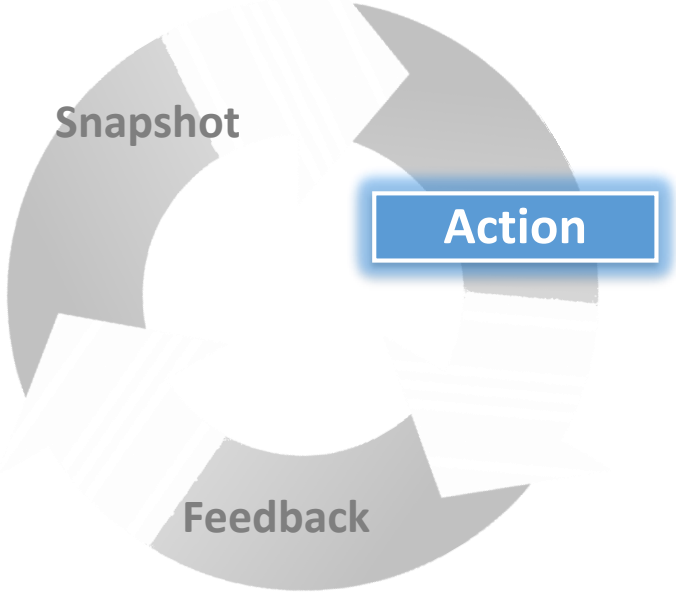
ANR – Snapshot

- **Identify sectors with high drops**
- **Suggest new NL**

ANR – Action

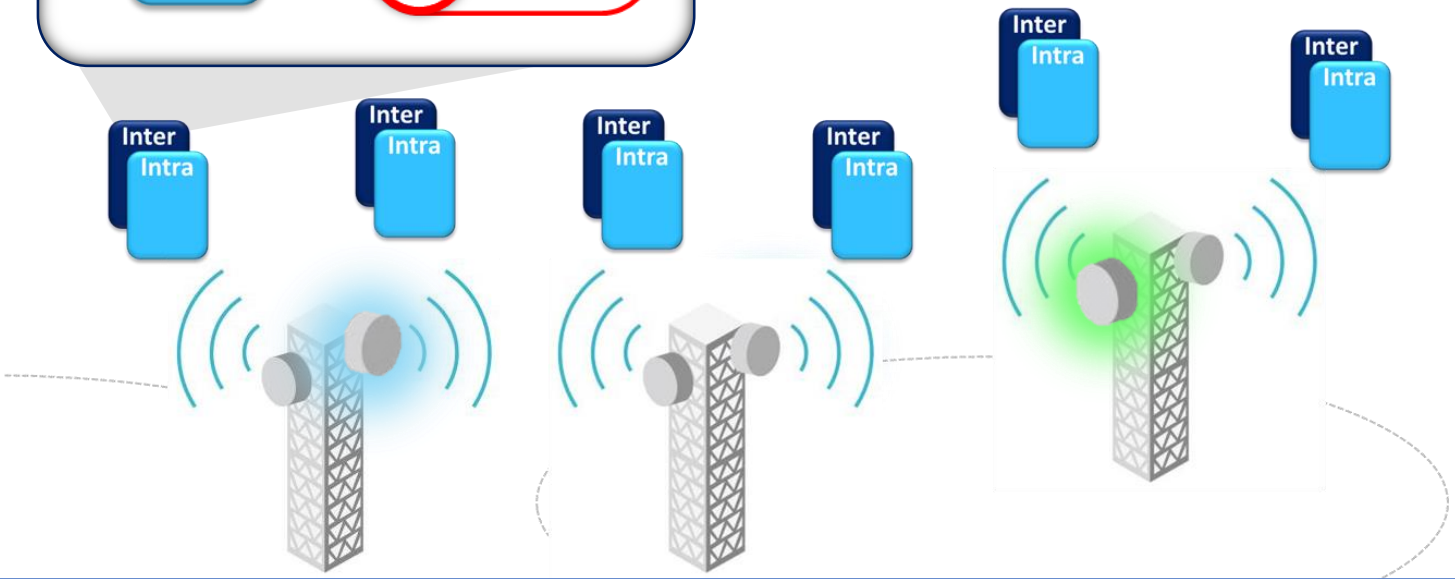
- **Configure sector**
- **Delete or add neighbors**





ANR – Feedback

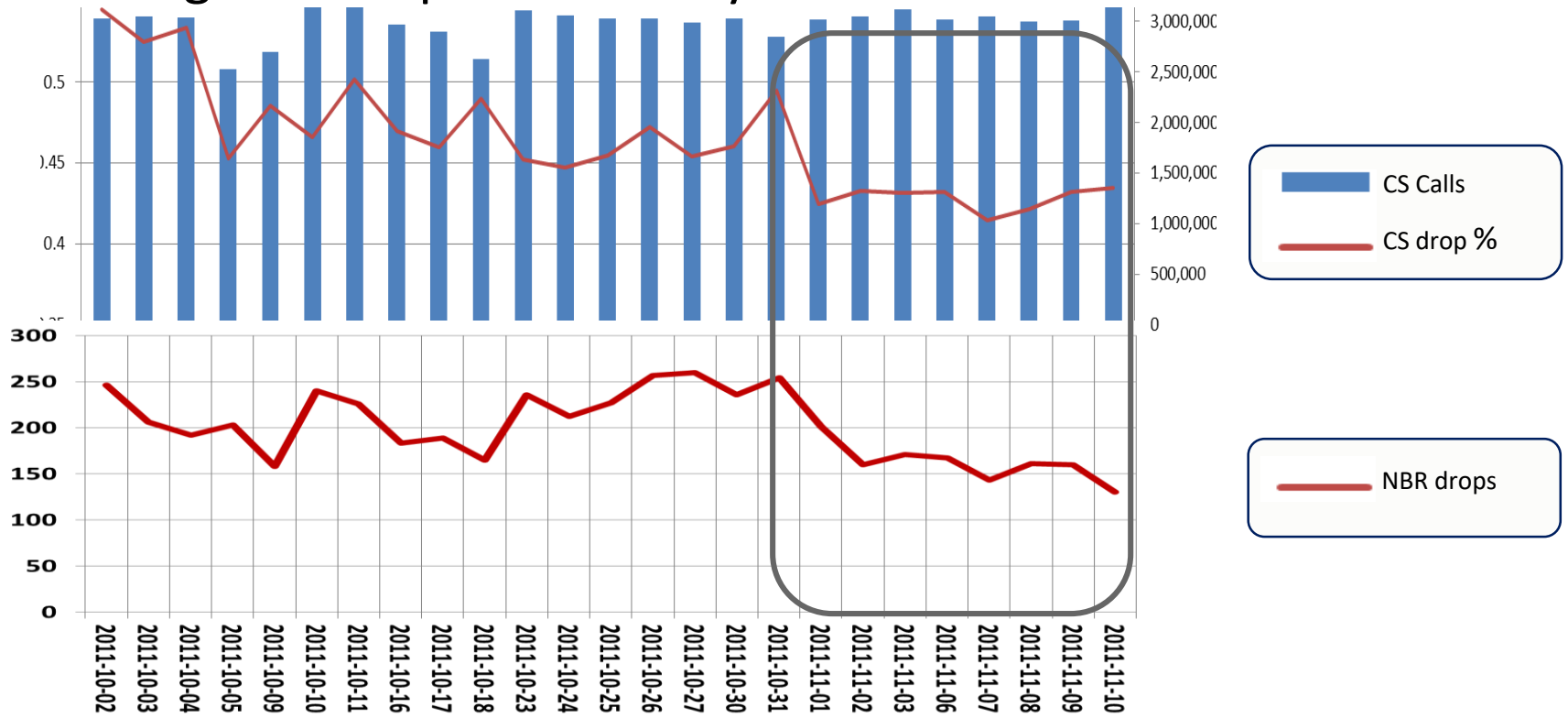
- **Validate modifications**
- **Submit or Restore changes**



ANR Improved performance on RNC KPIs

Call drop rate lowered by 9.1%

Neighbor drops lowered by 25%



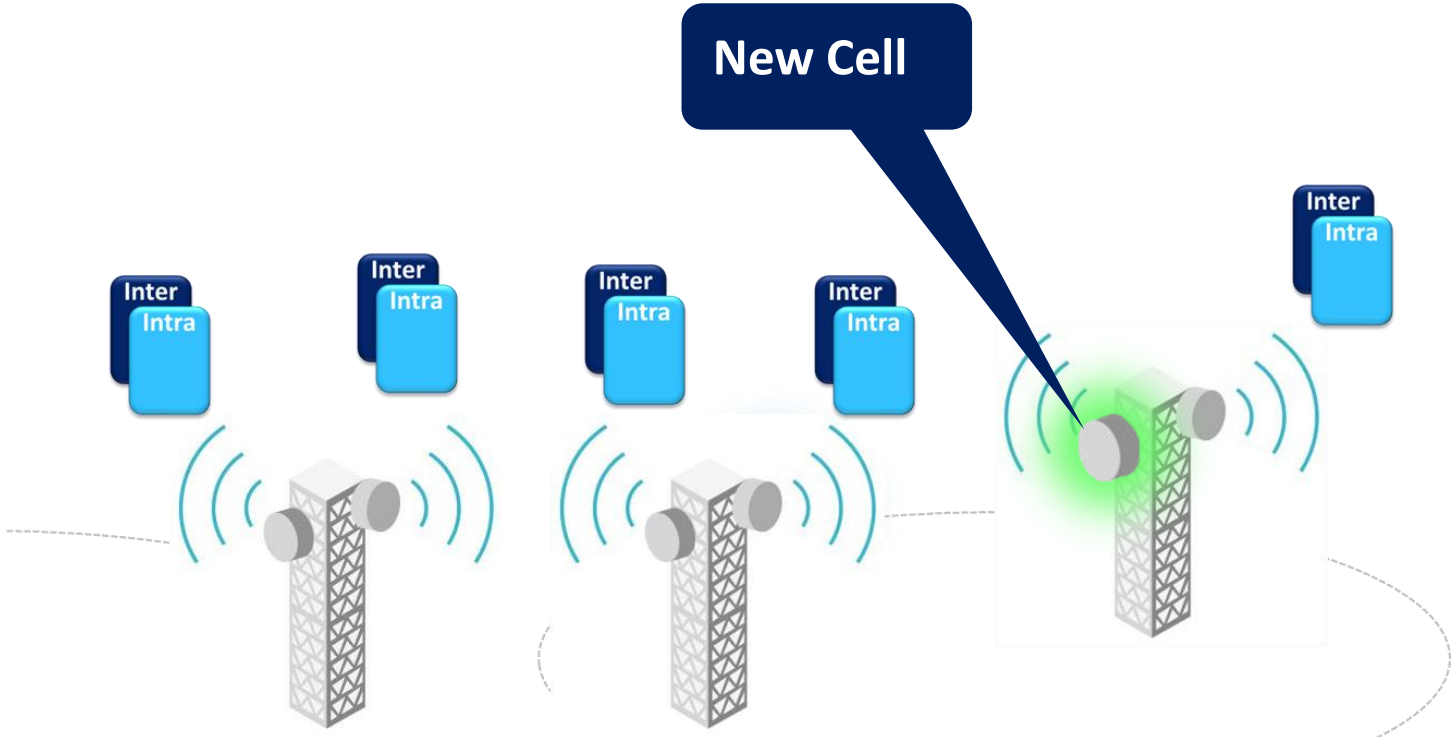
SONs Main Modules

- ANR – Automatic Neighbor Relation
- **APO – Automatic Parameter Organization**
- DLB – Dynamic Load Balancing
- ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
- DIM – Dynamic Interference Management

The APO Plug & Play Application

Maintains neighbor relations through engineer activities such as

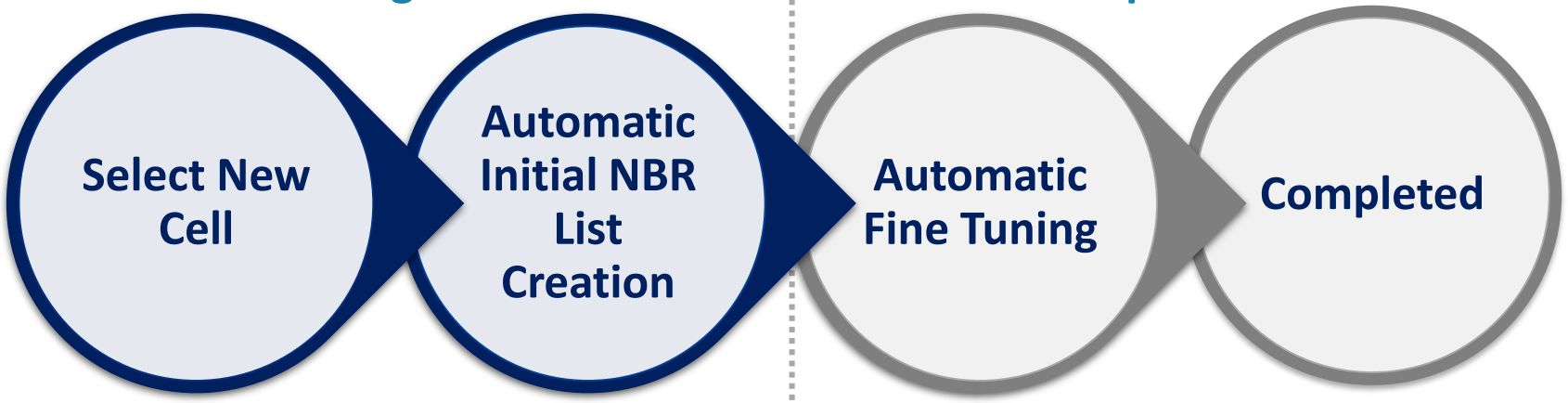
adding new cells, or moving cell locations

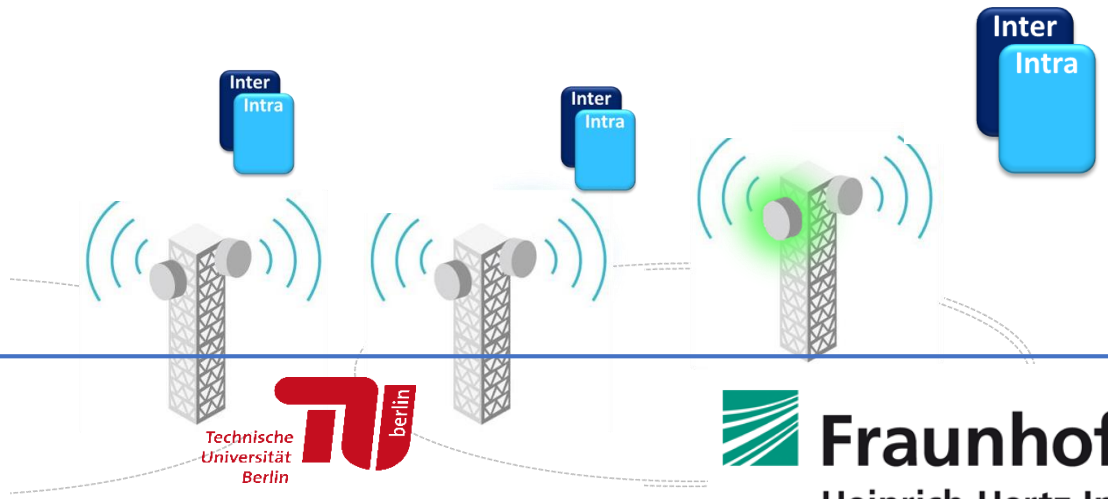


APO Plug & Play Manual Workflow

APO Plug & Play Module
Self Organization

Automatic Neighbor Relations
Self Optimization



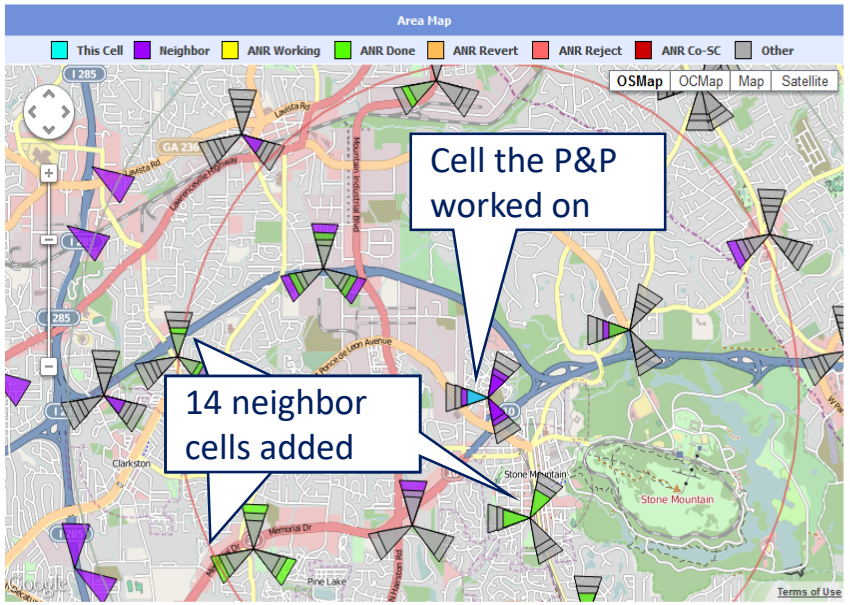


Technische Universität Berlin

Fraunhofer
Heinrich Hertz Institute

Self Configuration: Plug & Play

11 cells added automatically when the cell was identified by the self configuration system.



Recent Actions (2011-12-14 - 2011-12-20)

Type	Time	Status	Action		Neighbor ID	SC	Distance	Weight	# Missing	Add. Info
Reject	12/14 19:12	Rejected	Distance		103418039386	-	1.91 km	-	361	
Intra	12/15 10:27	Done	Add		103418039386	-	1.91 km	63.81%	-	
Reject	12/16 12:27	Rejected	Distance		103418010755	-	3.23 km	-	150	
Reject	12/16 12:27	Rejected	Distance		103418019186	-	4.71 km	-	60	
Pnp	12/16 16:57	Done	P&P		-	-	-	-	-	
Reject	12/20 21:43	Rejected	Distance		103418033394		km	-	84	

Symmetric and Second Order Actions (2011-12-14 - 2011-12-20)

Time	Cell ID	Status	Action	Neighbor ID	SC	Distance	Weight	Add. Info
12/15 10:27	103418039386	Done	Add (Symmetric)	103418033616	-	1.91 km	-	

Neighbor Data

Neighbor	Neighbor Id	Neighbor Carrier	Type	S.C	Distance	Weight %	Weight@Nbr %	Priority	Policy
GAATV33614	103418033614	437	Intra	311	0.0	23.80 %	28.38 %	7	-
GAATV39386	103418039386	437	Intra	233	1.91	46.37 %	14.76 %	5	-
GAATV10755	103418010755	437	Intra	26	3.23	9.35 %	10.48 %	5	-
GAATV10765	103418010765	437	Intra	78	4.35	4.17 %	8.01 %	5	-
GAATV10764	103418010764	437	Intra	423	4.35	4.26 %	7.33 %	5	-
GAATV33615	103418033615	437	Intra	146	0.0	3.41 %	4.09 %	8	-
GAATV10766	103418010766	437	Intra	21	4.35	0.50 %	0.97 %	5	-
GAATV19186	103418019186	437	Intra	442	4.71	4.71 %	0.52 %	5	-
GAATV10756	103418010756	437	Intra	326	3.23	1.39 %	0.51 %	5	-
GAATV39384	103418039384	437	Intra	148	1.91	1.44 %	0.19 %	5	-
GAATV36286	103418036286	437	Intra	31	3.66	0.59 %	0.05 %	5	-
GAATU35555	103418035555	437	Intra	489	4.97	0 %	0.02 %	5	-
GAATU06617	*8006617*	*412*	*Inter*	*311*	*0.0*	-	*0.00 %*	-	-

Added Neighbors:

103418039384 103418033366 103418010755
103418010754 103418010756 103418036284
103418036286 103418010766 103418010764
103418010765 103418019186 103447035356
103418035555 103418035554

High weight neighbors added automatically

Technische Universität Berlin

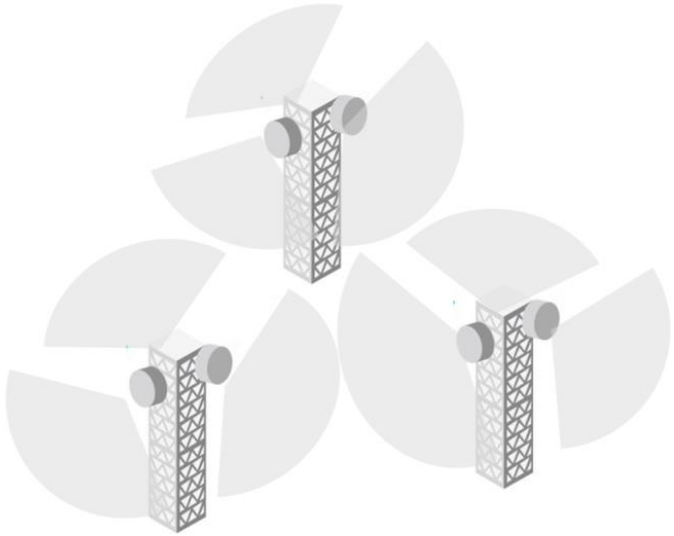
Fraunhofer Heinrich Hertz Institute

SONs Main Modules

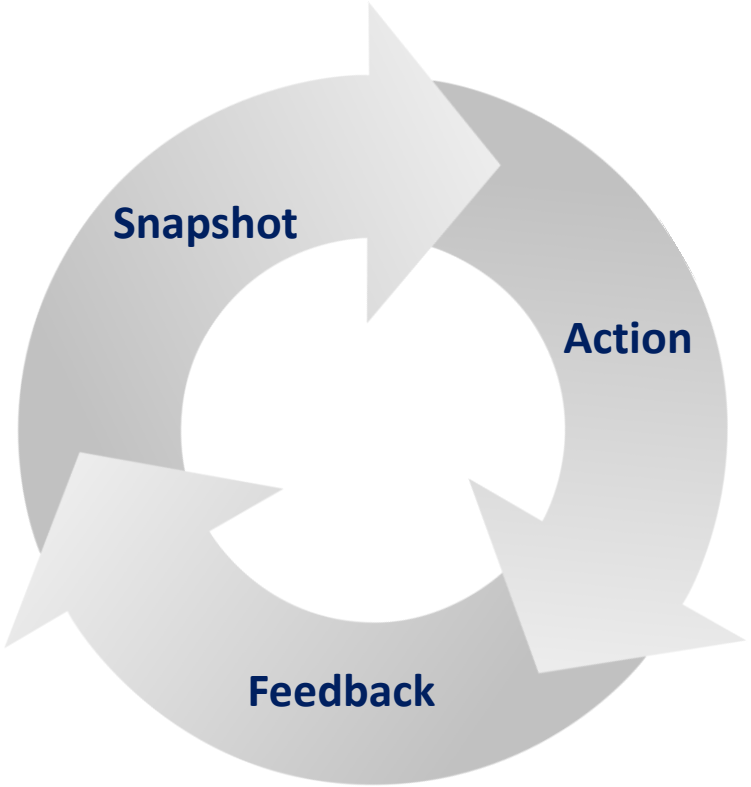
- ANR – Automatic Neighbor Relation
- APO – Automatic Parameter Organization
- **DLB – Dynamic Load Balancing**
- ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
- DIM – Dynamic Interference Management

The SON Load Balancing Application

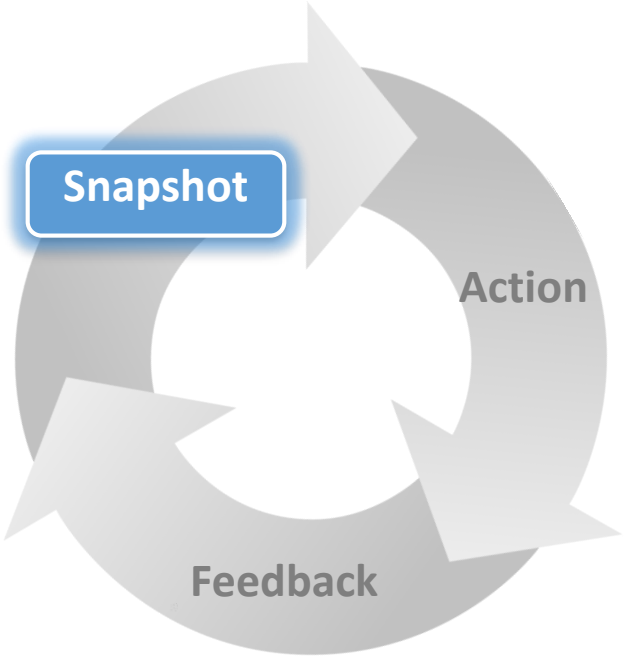
Provides a near-real time response to unpredictable load challenges on the network using RF-shaping



Load Balancing – How Does It Work?

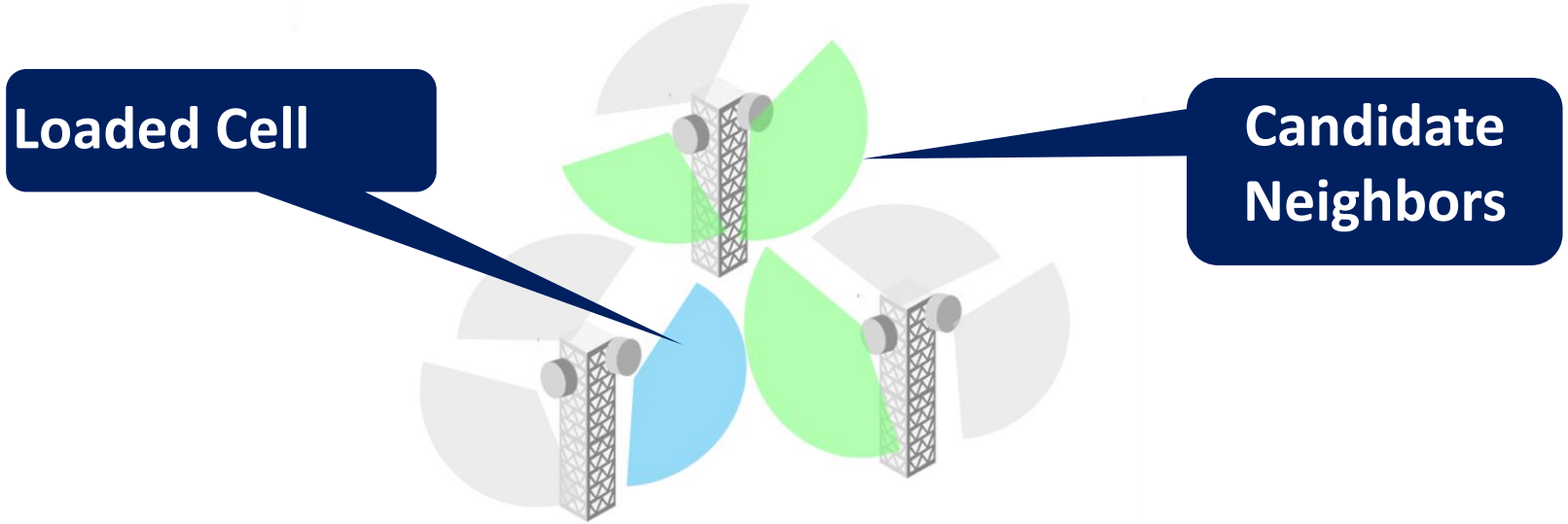


Load Balancing – Snapshot

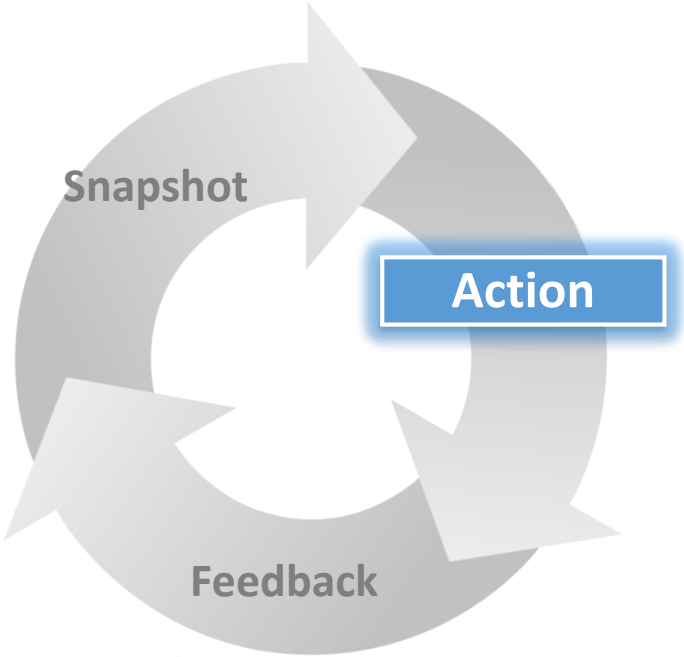


Triggered when detecting loads above thresholds

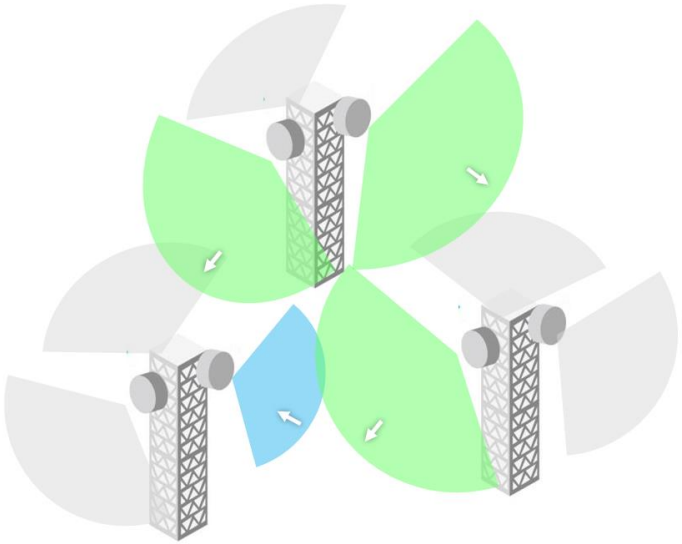
Generate a list of candidate neighbors to pass subscribers to



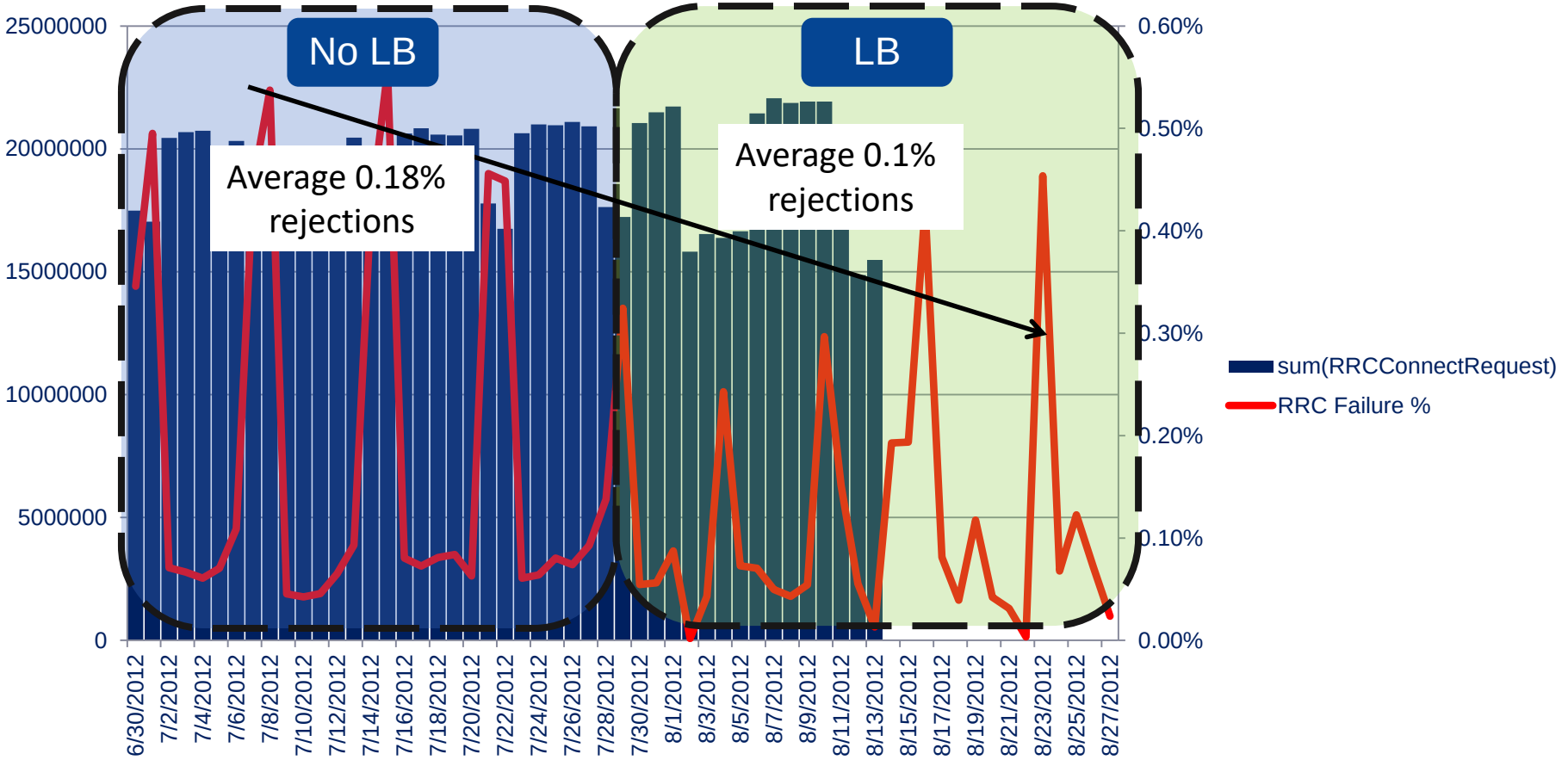
Load Balancing – Action



Configures RF parameters to move subscribers to other cells



LB: Admission rejections reduced by 50%



SONs Main Modules

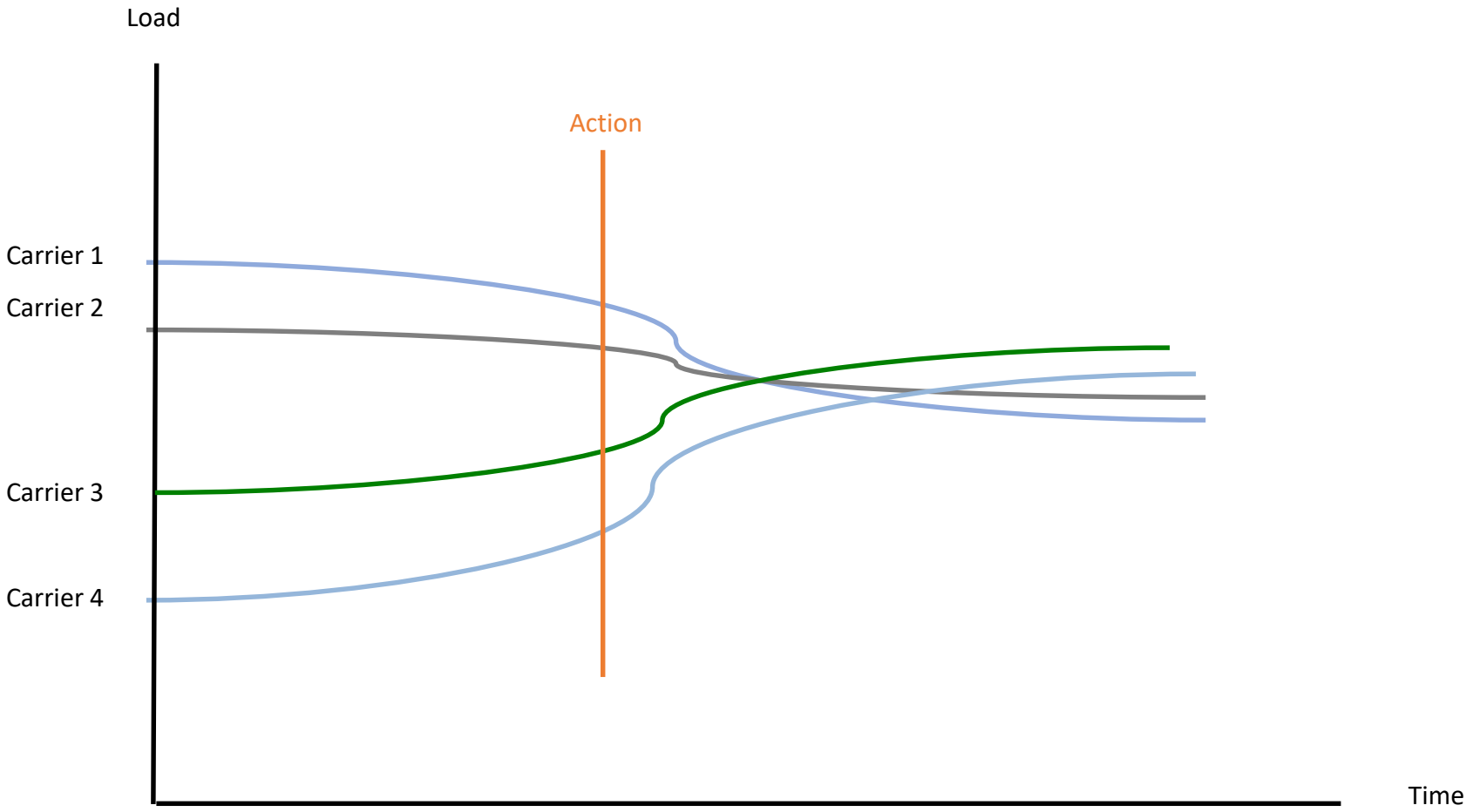
- ANR – Automatic Neighbor Relation
- APO – Automatic Parameter Organization
- DLB – Dynamic Load Balancing
- **ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling**
- DIM – Dynamic Interference Management

ICLB/MEH – Inter Carrier Load Balancing/Mass Event Handling

Technische Universität Berlin

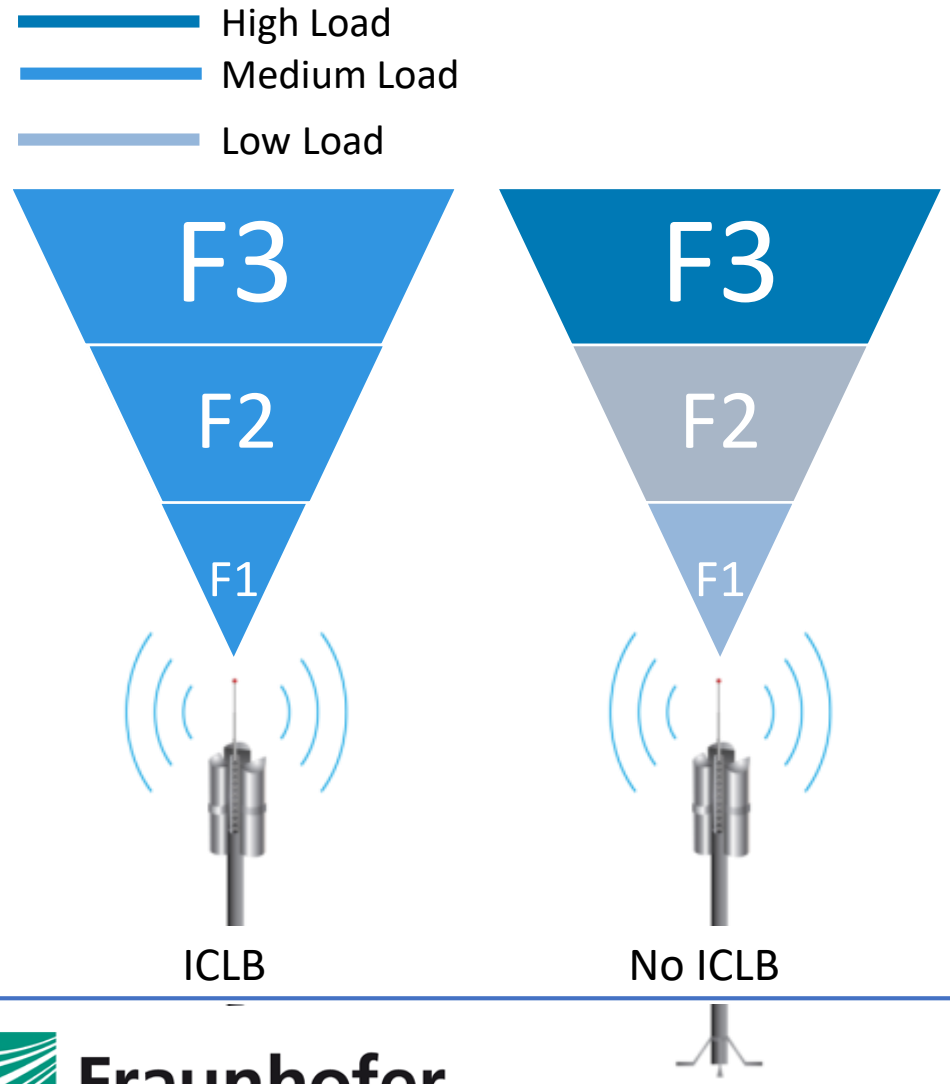
Fraunhofer Heinrich Hertz Institute

Motivation – Inter Carrier Load Balance



MEH/ICLB Description

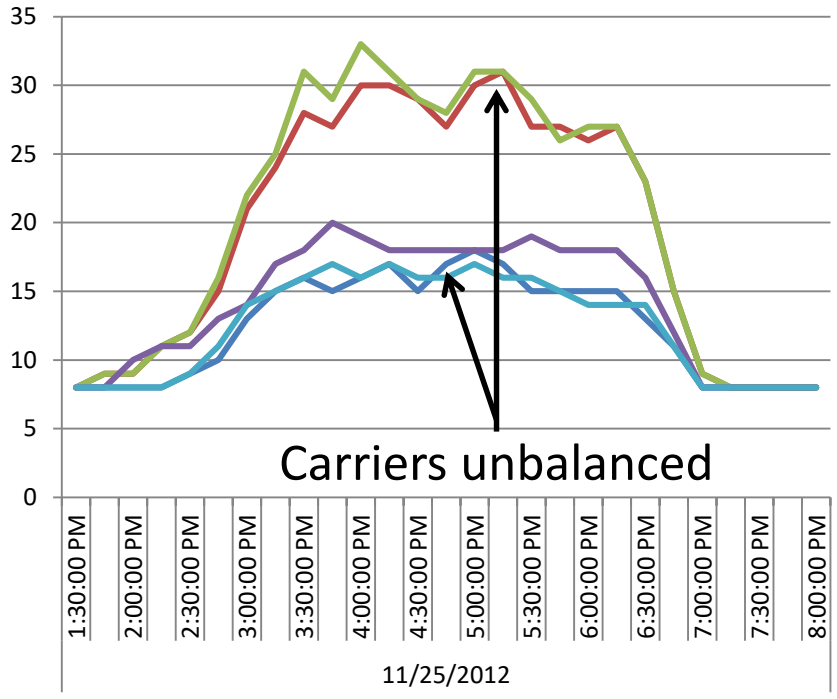
- Provides a near-real time response to the unpredictable load challenges
- Using carrier re-selection – effective on Idle UEs
- Balance the most congested radio resource (power / codes)
- Load balancing of resources and traffic across the available carriers



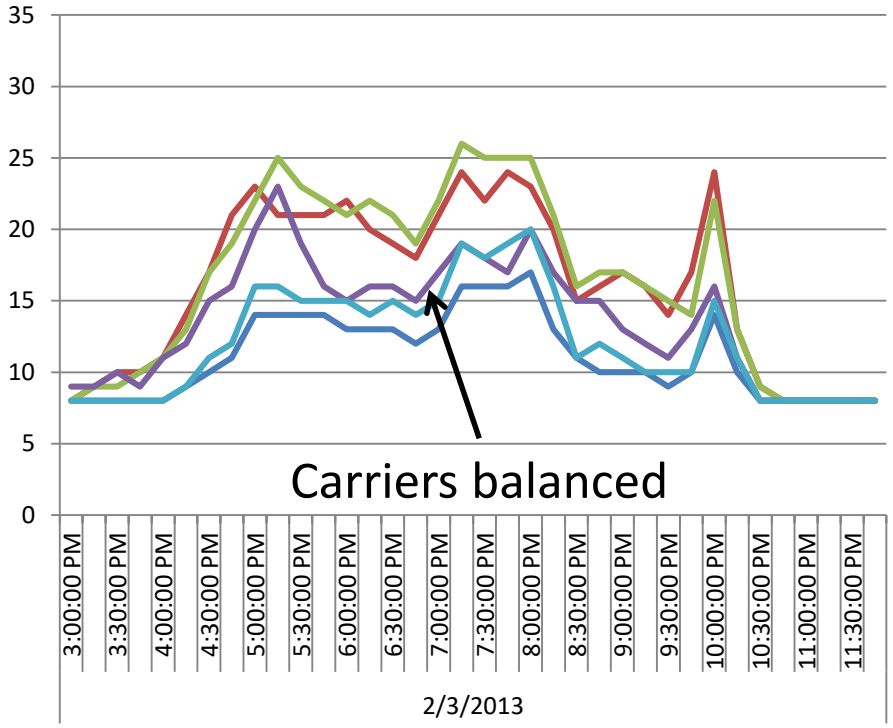
Superbowl MEH: RT resource sharing

ZONE 27 Code Load

25.11.2012: MEH Off, high imbalance



02.03.2013: MEH On, Traffic Balance

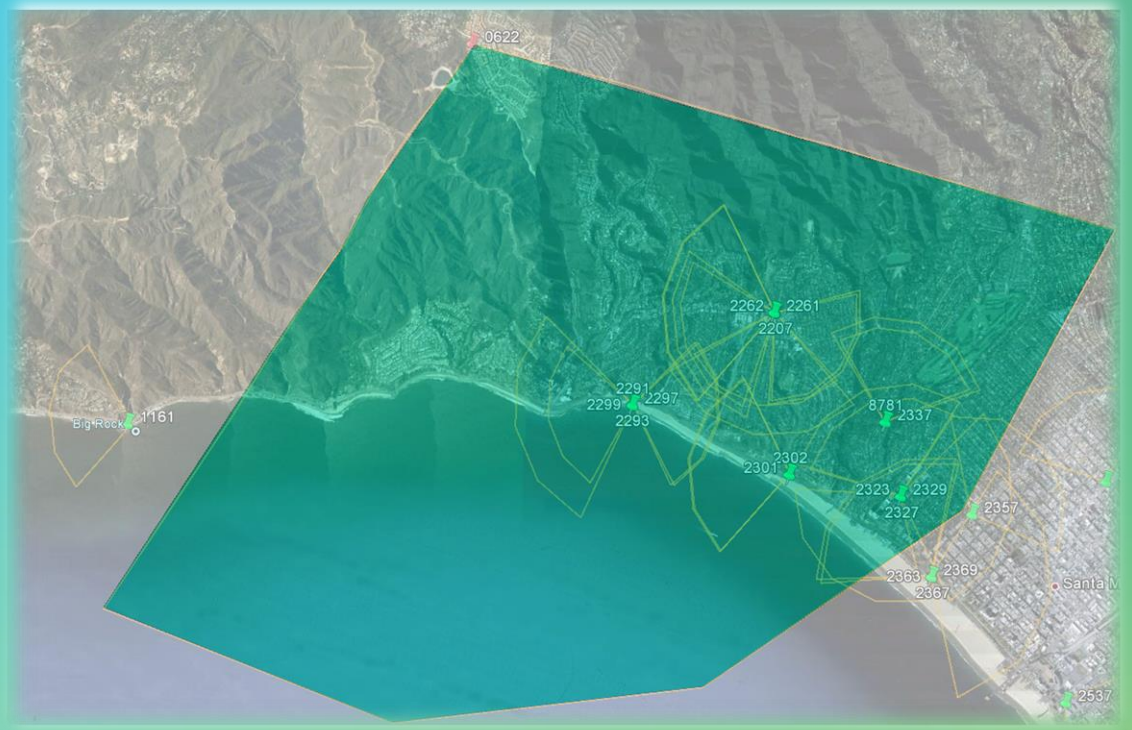


Technische Universität Berlin

Fraunhofer Heinrich Hertz Institute

SONs Main Modules

- ANR – Automatic Neighbor Relation
- APO – Automatic Parameter Organization
- DLB – Dynamic Load Balancing
- ICLB/MEH – Intra-Carrier Load Balancing and Mass Event Handling
- **DIM – Dynamic Interference Management**



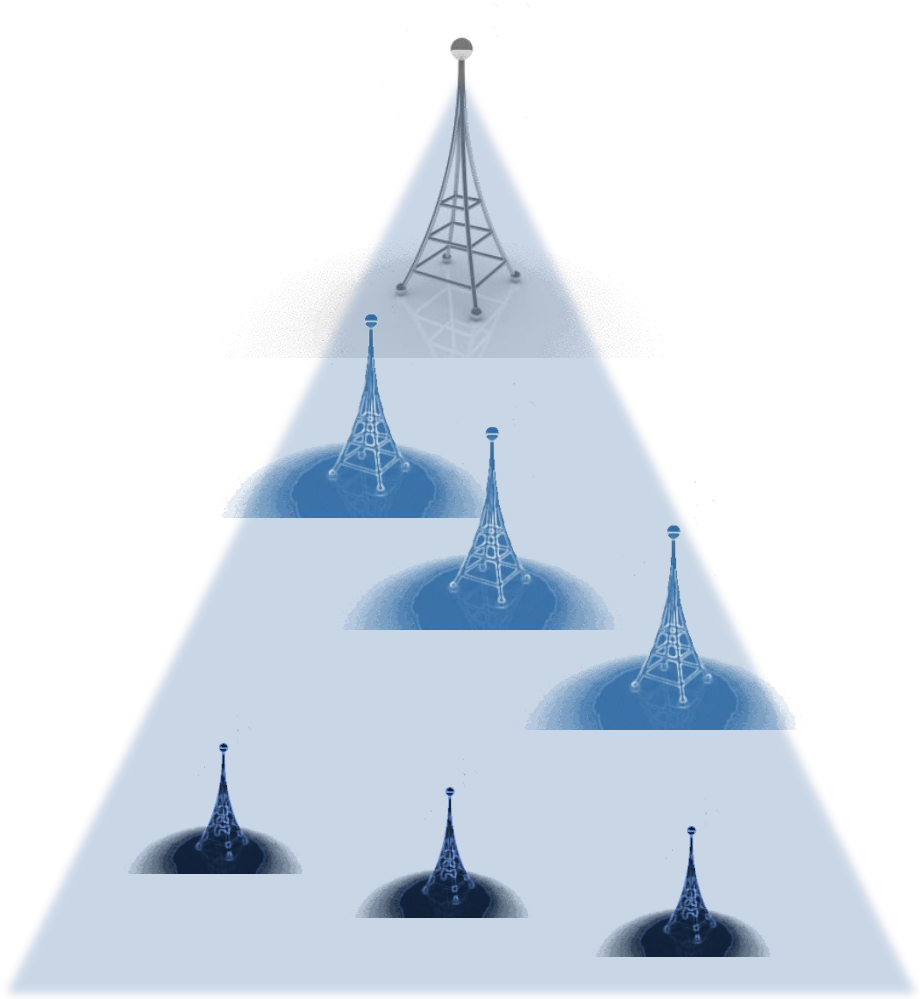
DIM - Dynamic Interference Management

Technische Universität Berlin

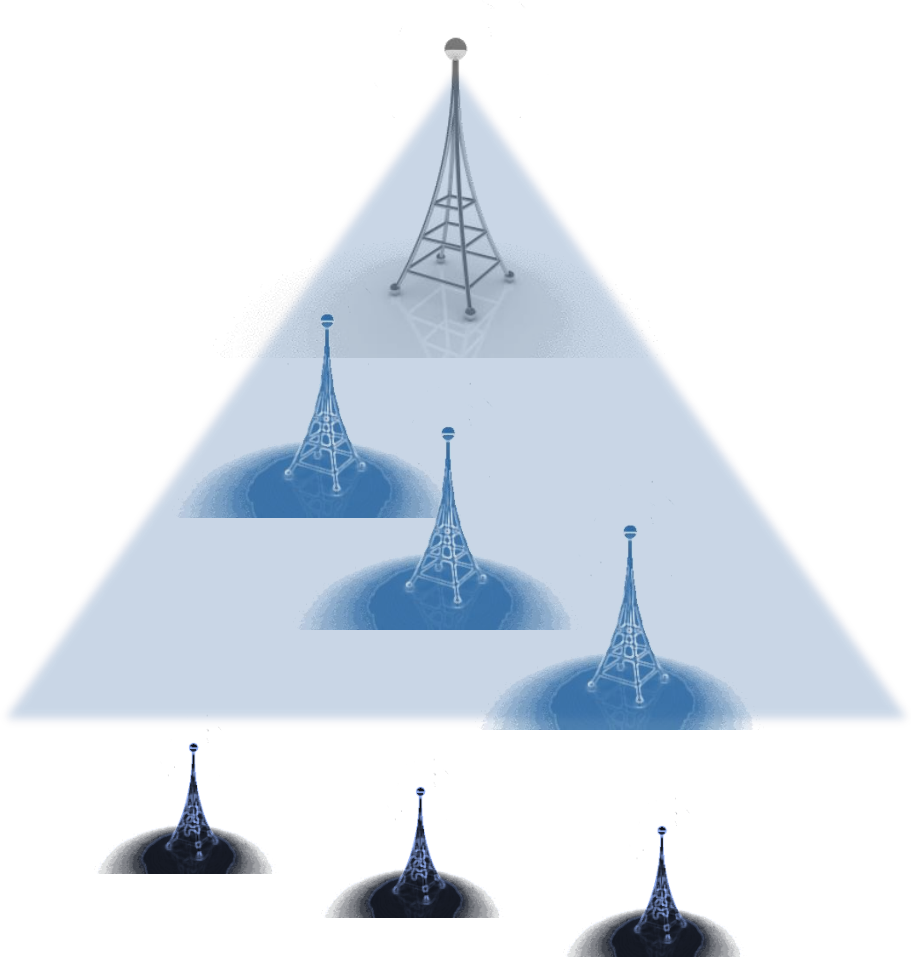
Fraunhofer Heinrich Hertz Institute

DIM Description

Before DIM action

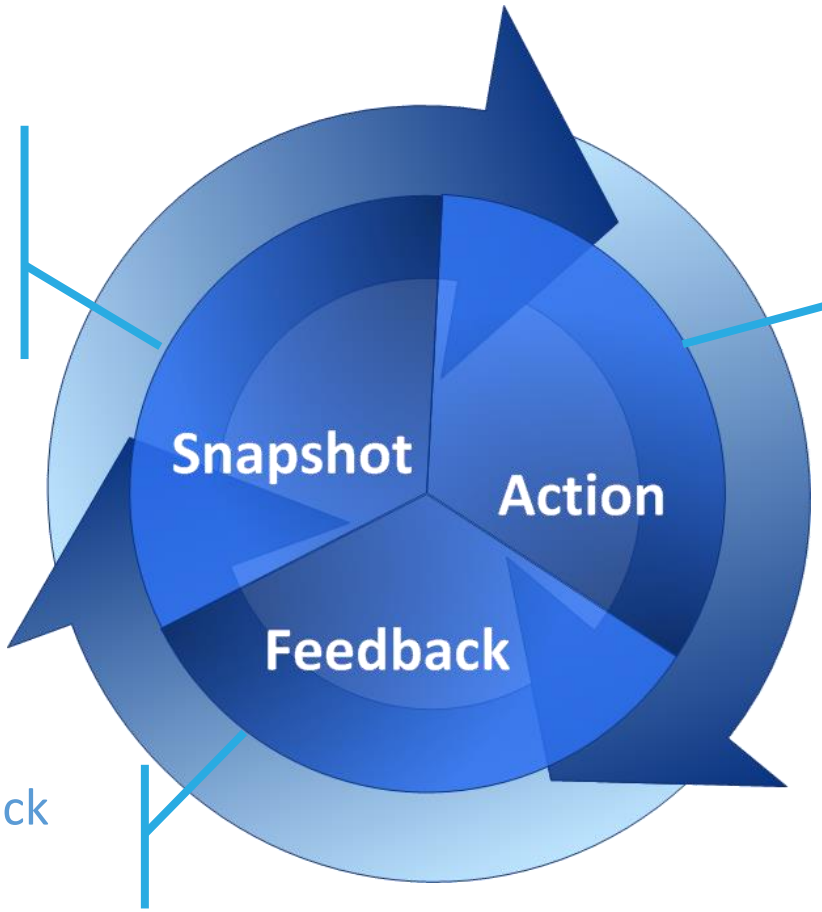


After DIM action



DIM Work Cycle

Detection of Overshooting Cells

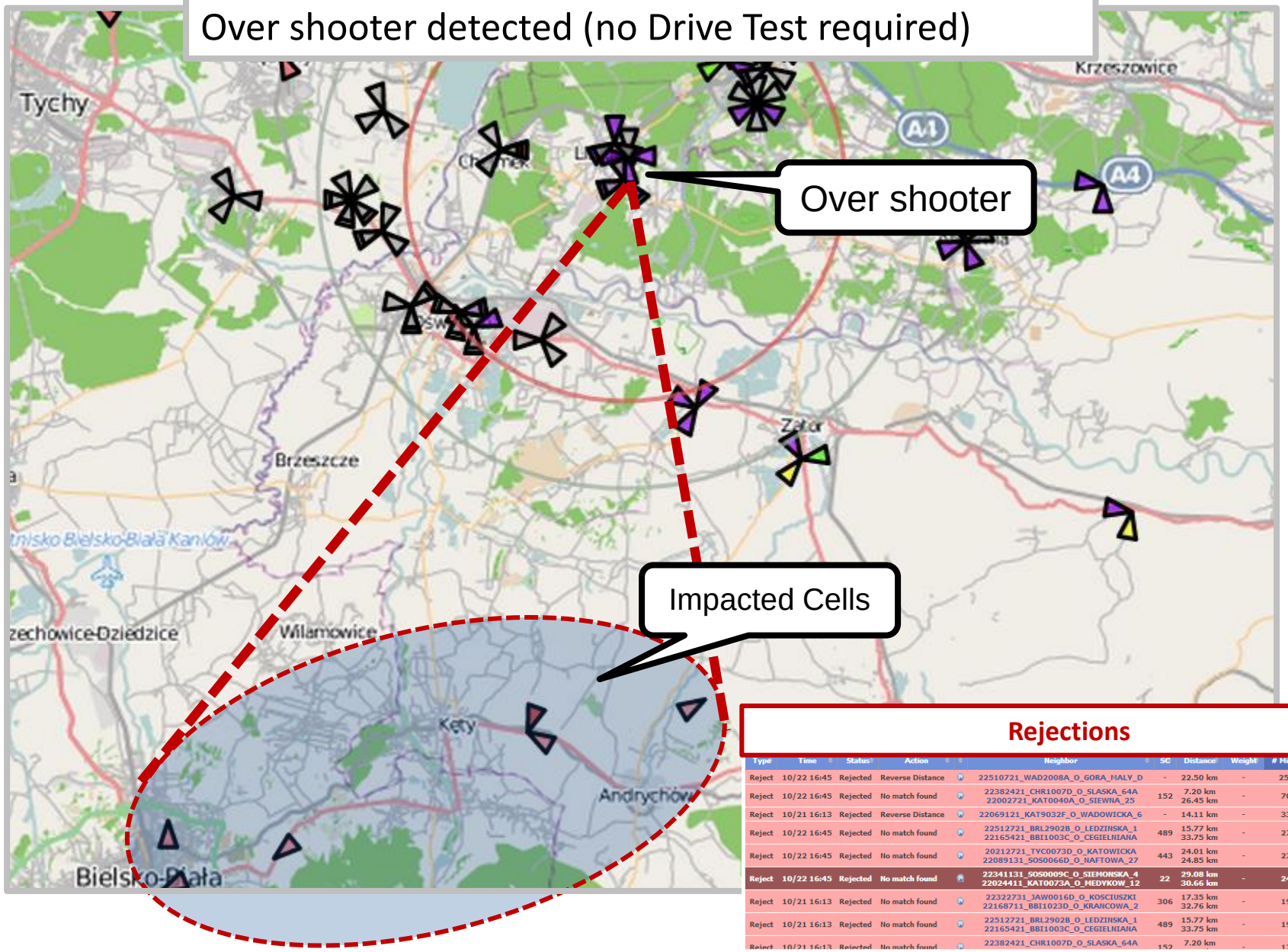


Tilt change

Automatic Feedback Detecting

Over shooter Detection -(Poland)

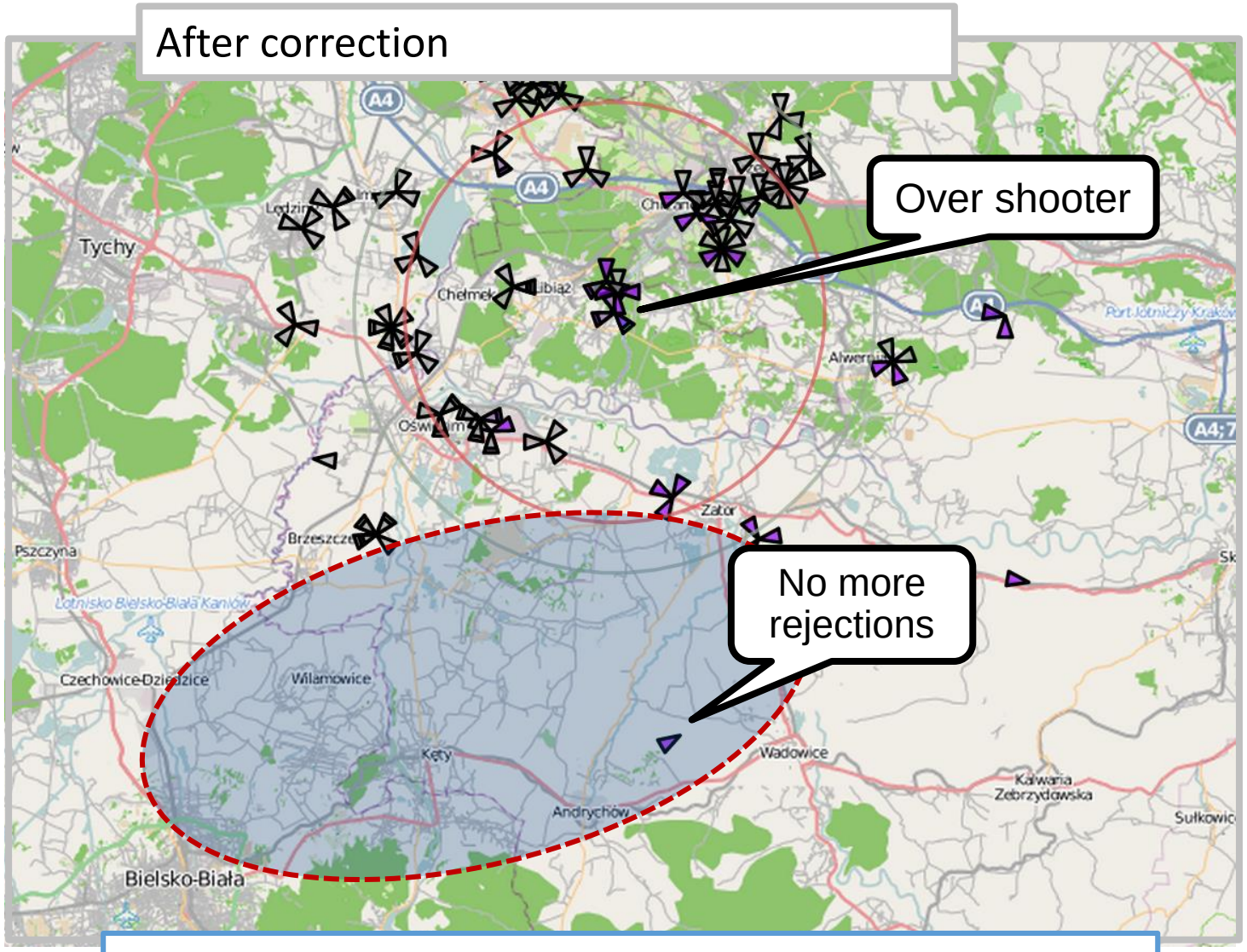
Over shooter detected (no Drive Test required)



Rejections

Type	Time	Status	Action	Neighbor	SC	Distance	Weight	# Missing	Overlap	Add. Info
Reject	10/22 16:45	Rejected	Reverse Distance	22510721_WAD2008A_O_GORA_MALY_D	-	22.50 km	-	2554	-	
Reject	10/22 16:45	Rejected	No match found	22382421_CHR1007D_O_SLASKA_64A 22002721_KAT0040A_O_SIEWNA_25	152	7.20 km 26.45 km	-	702	-	
Reject	10/21 16:13	Rejected	Reverse Distance	22069121_KAT9032F_O_WADOWICKA_6	-	14.11 km	-	330	-	
Reject	10/22 16:45	Rejected	No match found	22512721_BRL2902B_O_LEDZINSKA_1 22165421_BBI1003C_O_CEGIELNIANA	489	15.77 km 33.75 km	-	279	-	
Reject	10/22 16:45	Rejected	No match found	20212721_TYC0073D_O_KATOWICKA 22089131_SOS0066D_O_NAFTOWA_27	443	24.01 km 24.85 km	-	277	-	
Reject	10/22 16:45	Rejected	No match found	22341131_SOS0009C_O_SIEMONSKA_4 22024411_KAT0073A_O_MEDYKOW_12	22	29.08 km 30.66 km	-	245	-	
Reject	10/21 16:13	Rejected	No match found	22322731_JAW0016D_O_KOSCIUSZKI 22168711_BBI1023D_O_KRANCOWA_2	306	17.35 km 32.76 km	-	198	-	
Reject	10/21 16:13	Rejected	No match found	22512721_BRL2902B_O_LEDZINSKA_1 22165421_BBI1003C_O_CEGIELNIANA	489	15.77 km 33.75 km	-	190	-	
Reject	10/21 16:13	Rejected	No match found	22382421_CHR1007D_O_SLASKA_64A	152	7.20 km	-	172	-	

Over shooter after correction



Drive Test Savings!!

Supervisor

- Supervisor :Prof. Dr.-Ing. Slawomir Stanczak
  Head of Wireless Communications and Networks Deprtment
  Heinrich Hertz Institute.

Thank you

Backup

Reproducing Kernel Hilbert Space (RKHS)

(RKHS). A Hilbert space $\mathcal{H}$ is called a Reproducing Kernel Hilbert Space (RKHS) if there exists a (kernel) function $\kappa : \mathbb{R}^m \times \mathbb{R}^m \to \mathbb{R}$ for which the following properties hold [STC04]:

1. $\forall \boldsymbol{x} \in \mathbb{R}^m$, the function $\kappa(\boldsymbol{x}, \cdot) : \mathbb{R}^m \to \mathbb{R}$ belongs to $\mathcal{H}$, and
2. $\forall \boldsymbol{x} \in \mathbb{R}^m, \forall f \in \mathcal{H}, \; f(\boldsymbol{x}) = \langle f, \kappa(\boldsymbol{x}, \cdot) \rangle$,

where the second property is called the reproducing property.

Convex Set und Convex Function

(Convex set). A set $C \subset \mathcal{H}$ is called convex if $\forall \boldsymbol{y}_1, \boldsymbol{y}_2 \in C$ and $\forall \lambda \in [0, 1]$

$$\lambda \boldsymbol{y}_1 + (1 - \lambda)\boldsymbol{y}_2 \in C.$$

If a set C contains all its boundary points, it is called *closed*. We use $d(\boldsymbol{x}, C)$ to denote the Euclidean distance of a point $\boldsymbol{x}$ to a closed convex set C. Thus,

$$d(\boldsymbol{x}, C) := \inf\{\|\boldsymbol{x} - \boldsymbol{y}\| : \boldsymbol{y} \in C\}.$$

(Convex function). A function $f : \mathcal{H} \to \mathbb{R}$ is called convex if $\forall \boldsymbol{y}_1, \boldsymbol{y}_2 \in \mathcal{H}$ and $\forall \lambda \in (0, 1)$

$$f(\lambda \boldsymbol{y}_1 + (1 - \lambda)\boldsymbol{y}_2) \leq \lambda f(\boldsymbol{y}_1) + (1 - \lambda) f(\boldsymbol{y}_2).$$

If the inequality holds strictly, f is called strictly convex.

The *projection* of $\boldsymbol{x}$ onto a nonempty closed convex set C, denoted by $P_C(\boldsymbol{x}) \in C$, is the uniquely existing point in the set

$$\operatorname{argmin}_{\boldsymbol{y} \in C} \|\boldsymbol{x} - \boldsymbol{y}\|.$$