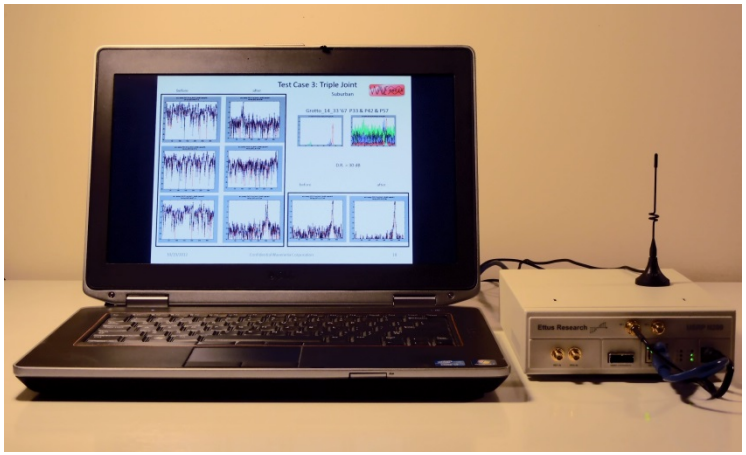
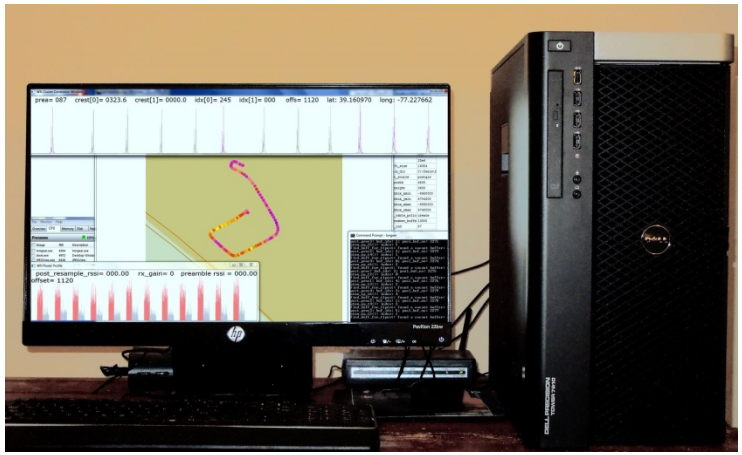
HIGH DYNAMIC RANGE PLATFORM FOR OFDMA SIGNAL COLLECTION AND PROCESSING USING JOINT DETECTION

SDR-WInnComm '15
March 26, 2015

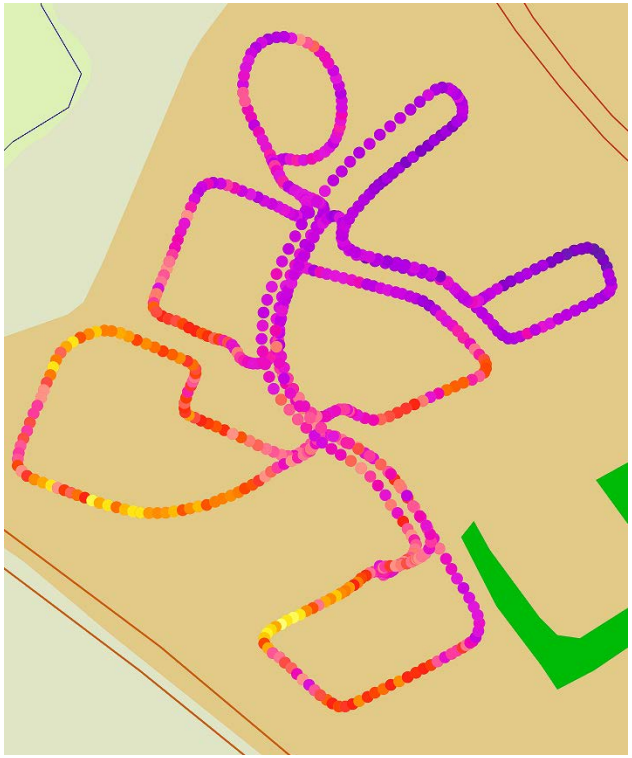


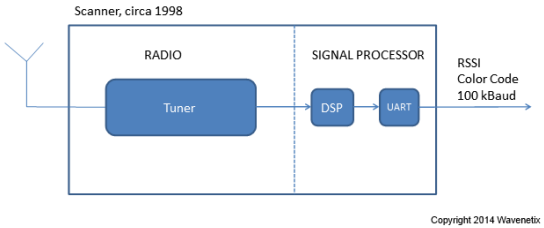


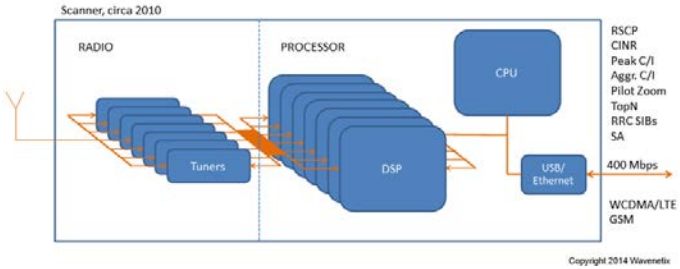
Contents

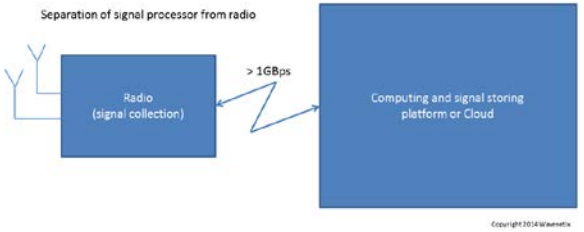
Introduction: RF Scanners

- Uses of scanners
- Traditional scanner, evolution, dead end
- Scanner market decline
- SON, indoor systems, het nets: new beginning
- Soft scanner: leveraging GP computing technology
- Longear project at Wavenetix: 3 years in development. A multithreading HPC system for signal collection and processing

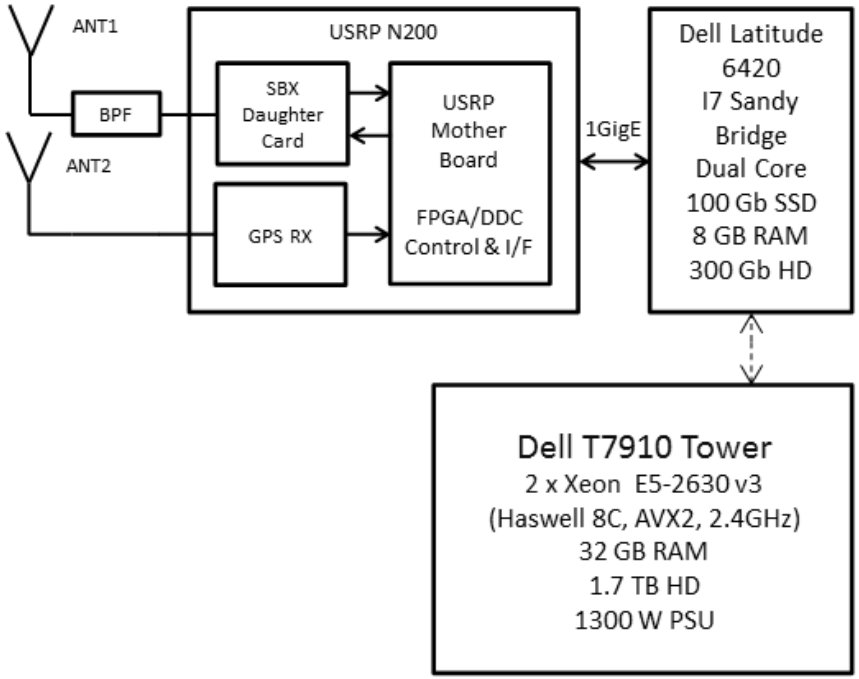








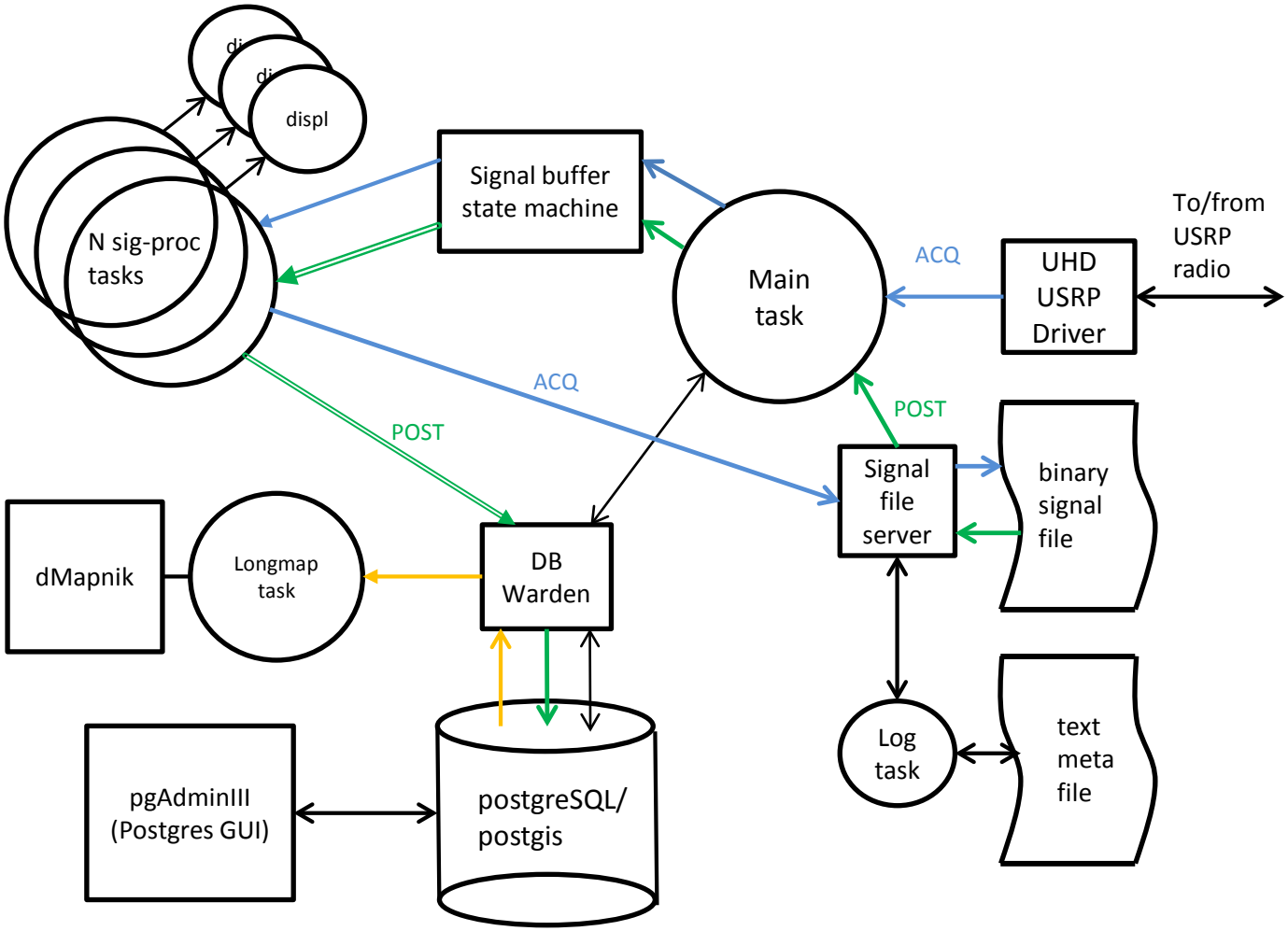
System description



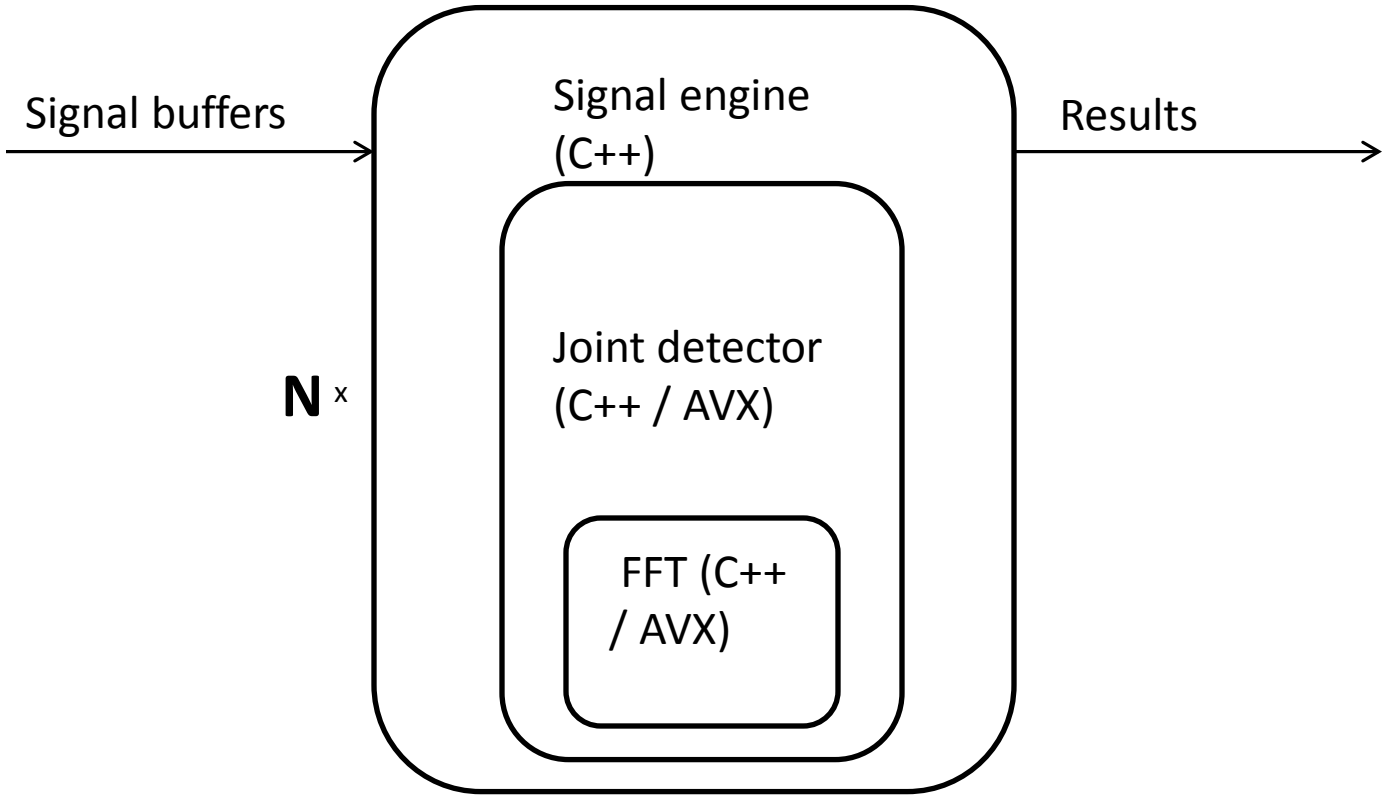
RF frequency range	400 – 4000 MHz
BW	10 MHz
RX output complex sample rate	25 Msps
RX output sample size	2 x 16-bit integer words
Signal storage medium	SSD, 100 GB
Storage sample rate, complex samples	11.2 Msps
Storage formats	Frame-synchronous binary file with headers; GPS-message text file
Database	progreSQL/postgis
GIS component / data source	Mapnik / OpenStreetMap

- ACQ: signal acquisition mode
- POST: signal post processing mode
  - ✓ 5 processing tasks/threads on laptop;
  - ✓ 15 tasks on workstation

Software architecture (1)



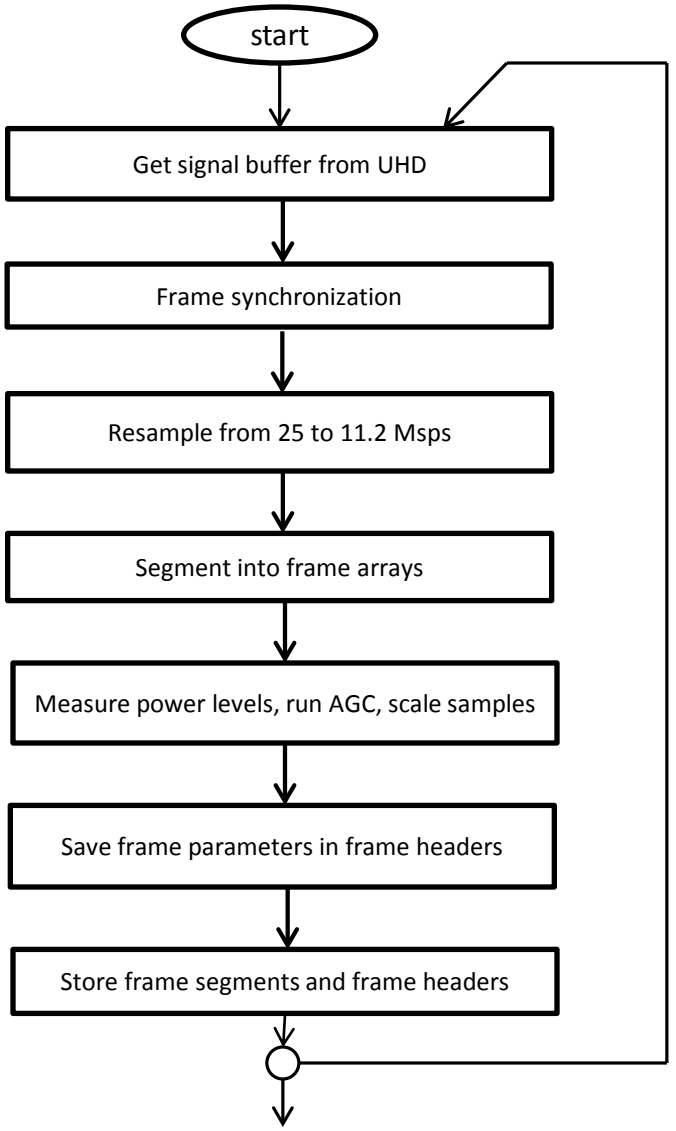
Software architecture (2)



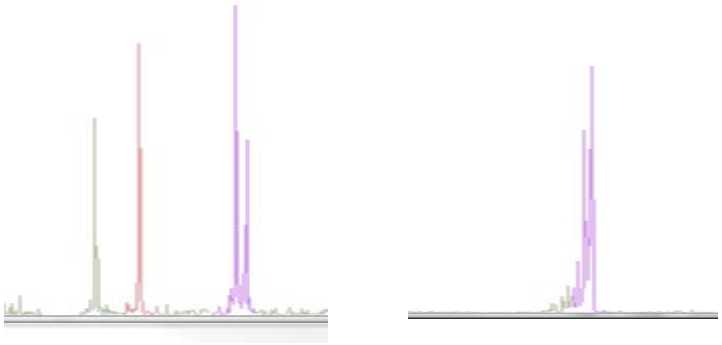
Note: N is a configuration parameter stored in the database

ACQ mode

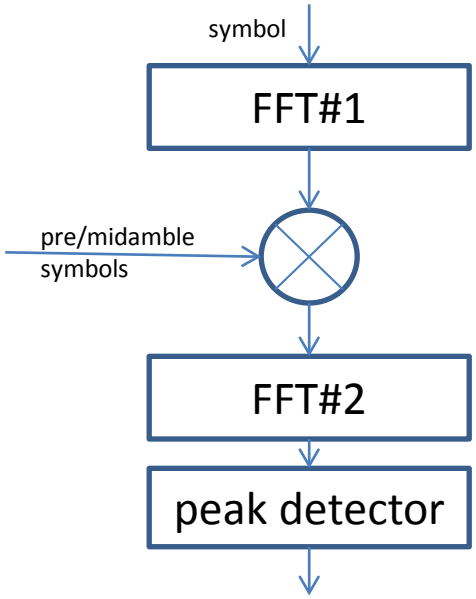
Signal samples come from the receiver via the UHD driver. Each signal “buffer” is a contiguous interval that contains several frames.

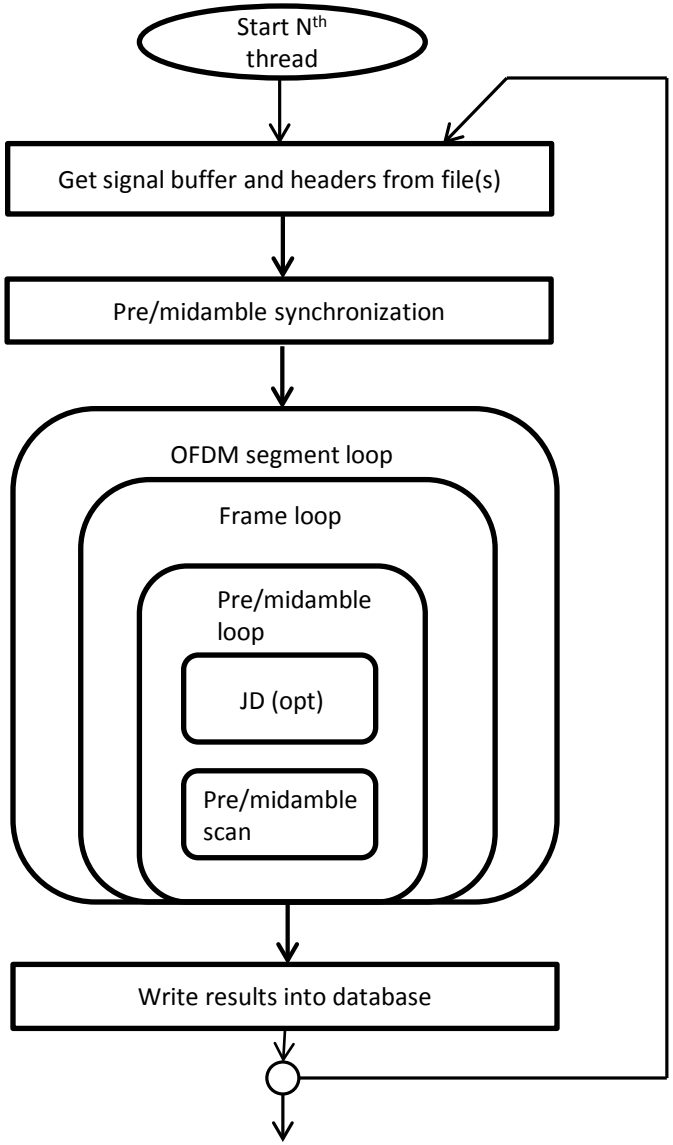


POST mode

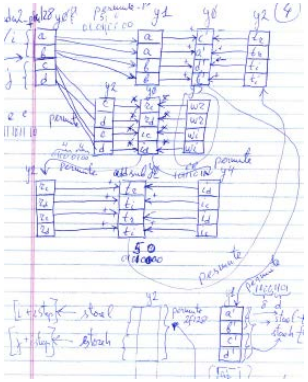


Basic OFDM correlation detector:



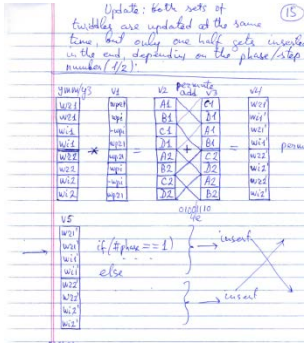


FFT class



Advantages of implementing FFT as a class:

- An instance of FFT in a sig-proc thread gets its static memory independent of other threads.
- Static arrays for storing signals make function calls more efficient; memory use is not of concern.
- An example of beneficial use of static storage is storing a LUT for bit reversal operation as a member of this class. It is generated during object initialization.



FFT optimization steps:

- Started with the classic “Numerical Recipes” code (Lanczos-Daniels algorithm).
- Unrolled first and last loop iterations.
- Tailored code to specific FFT size.
- Treated std::complex<float> arrays as pairs of interleaved real numbers by using C pointers.
- The code uses Intel AVX intrinsics throughout. Each operation typically involves eight floats. This lets the code do two butterflies in one iteration.
- Use of a look-up table for bit reversal step.

ITERATIVE INTERFERENCE CANCELLATION(1)

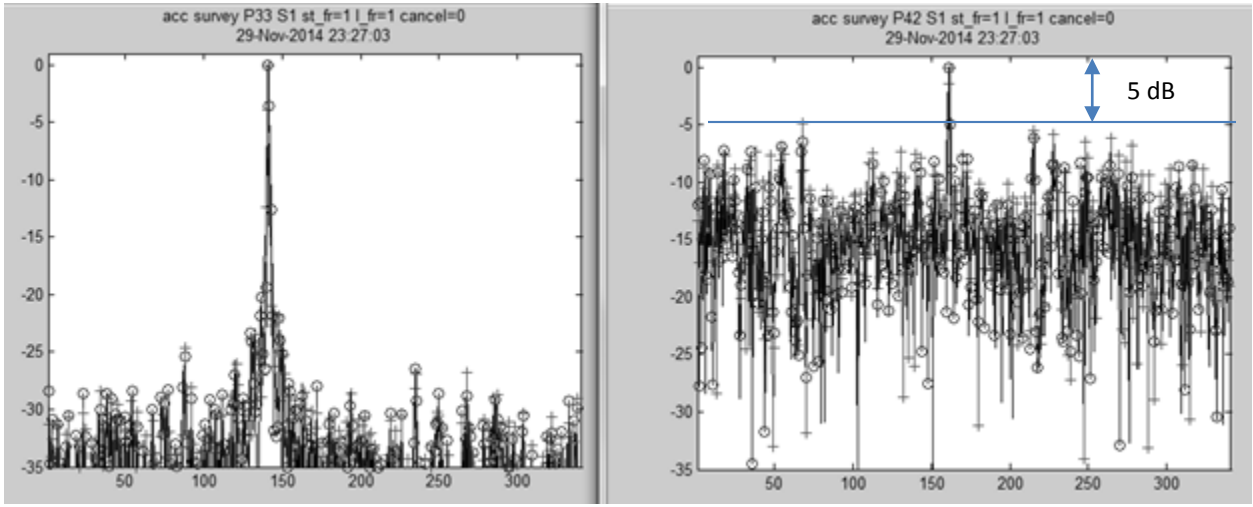
Signal discernibility depends on the length of the code used for signal identification.

The processing gain:	$Gproc = 10 \cdot \log_{10}(n)$;
SINR sufficient for reliable detection:	12 dB;
Discernibility (rule of thumb):	12 – Gproc.

Code lengths, processing gains, and discernibility of current and older air protocols:

- GSM: ~150 symbols / 22 dB / 12 – 22 = **-10 dB**
- IS-95: 32K / 45 dB / 12 – 45 = **-33 dB**
- WCDMA '99: 38K / 46 dB / 12 – 46 = **-34 dB**
- 802.16e, 10 MHz: 284 / 24.5 dB / 12 – 24.5 = **-12.5 dB**

Example: two signals, S1/S2 = 12 dB, no IC :

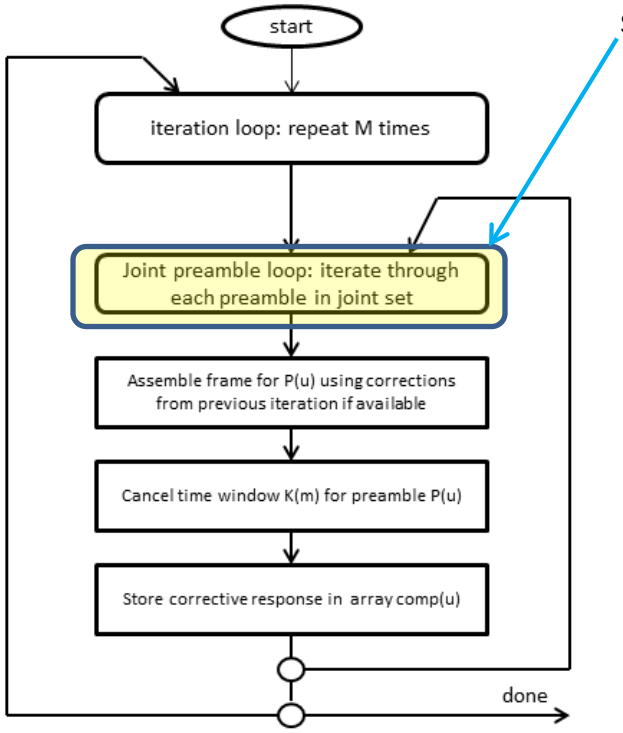


ITERATIVE INTERFERENCE CANCELLATION(2)

“Parallel” and “Series” interference cancellation (definition):

- Parallel IC (“pic”) attempts to cancel all of the suspected interferers at each step.
- Series IC (“sic”) cancels only the strongest interferer at each step, minimizing probability of error.

PIC flow chart



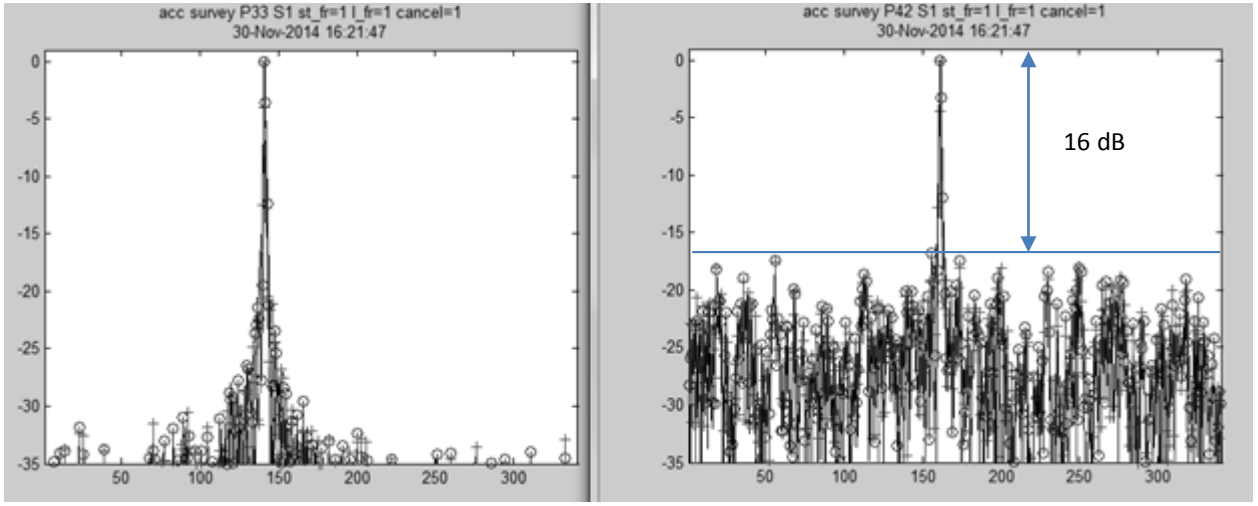
SIC: Joint preamble loop is replaced by the “analysis” step, which finds the strongest response to cancel.

Parameter	PIC	SIC	Comment
Number of iterations	4	12 - 64	Depends on the number of joint signals or how many of them are present in the air (2 – 6); also depends on CIR length. Set by user.
Number of preambles treated in each iteration	2 – 6	1	PIC: all preambles in the set even if not detected
Cancel window size, chips	16 , 16, 32, 34	5	PIC: different window size depending on iteration number
Total number of elementary (chip) cancellations per joint preamble	98	6 - 16	

ITERATIVE INTERFERENCE CANCELLATION(3)

Simulated signals

Two preambles at 12 dB level difference that are processed using PIC:



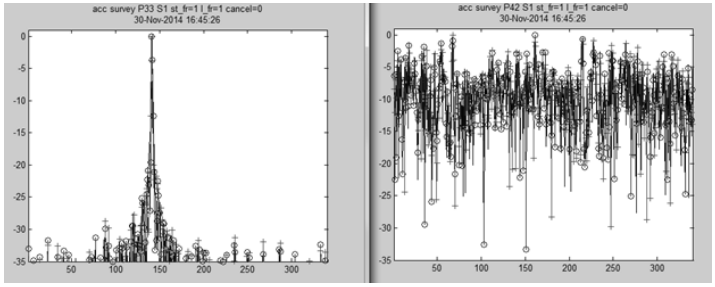
	NO IC	PIC
Level delta, dB	12	12
Discernibility, dB	5	16

ITERATIVE INTERFERENCE CANCELLATION(4)

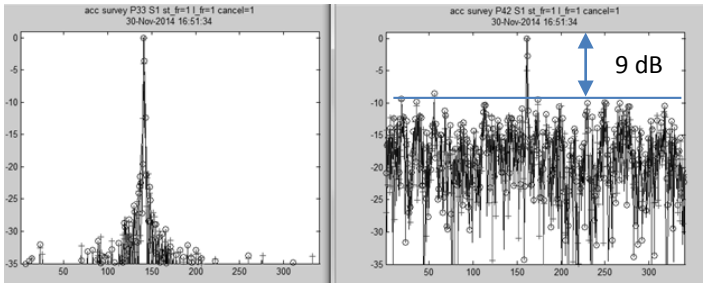
Simulated signals

Two preambles at 20 dB level difference processed using PIC and SIC:

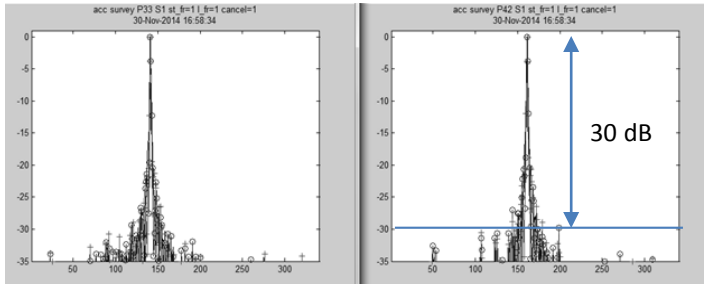
NO IC



PIC



SIC

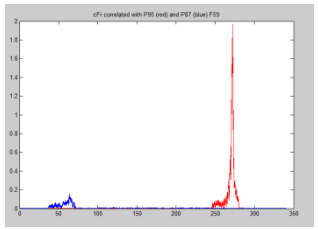


	NO IC	PIC	SIC
Level delta, dB	20	20	20
Discernibility, dB	0	9	30

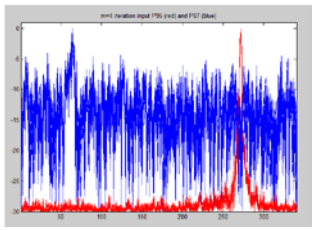
FIELD PERFORMANCE TESTS(1)

Stationary position, rural, PIC Lewis_Orchard_17_30 2667 MHz

Signal models

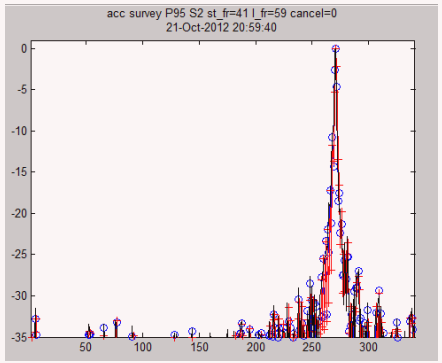


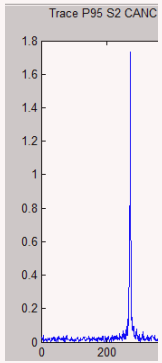
P95: 5.3 mi
P87: 8.7 mi

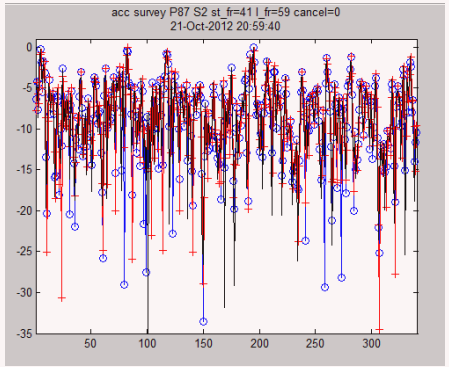


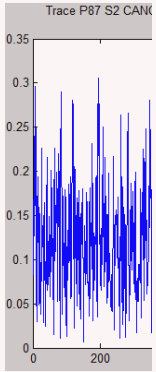
Correlations with the jointly detected preambles at the input to the last iteration

No joint detection

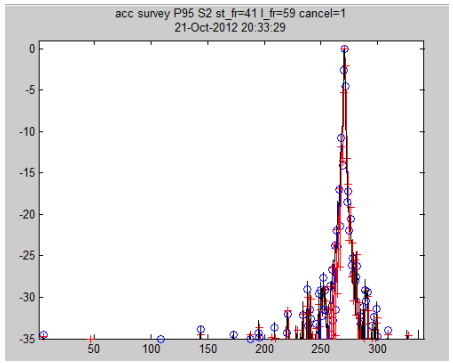


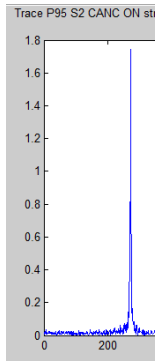


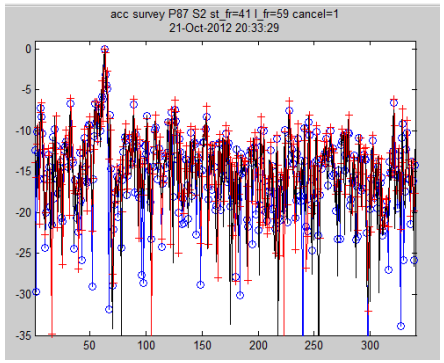


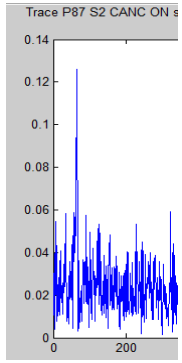


After joint detection: P95 & P87







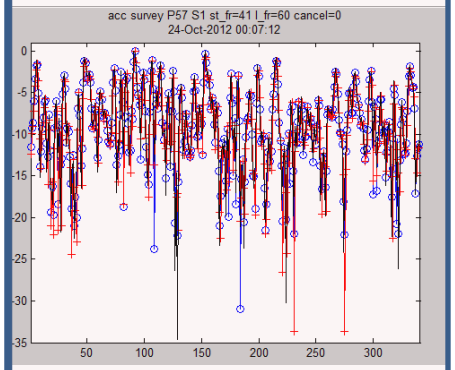


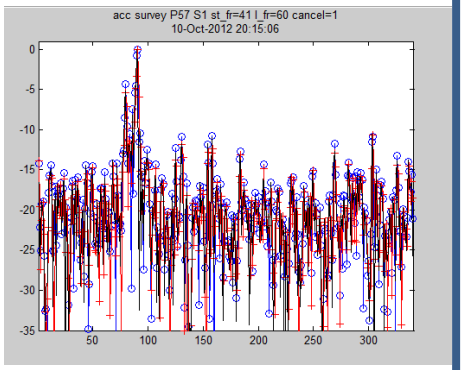
FIELD PERFORMANCE TESTS(2)

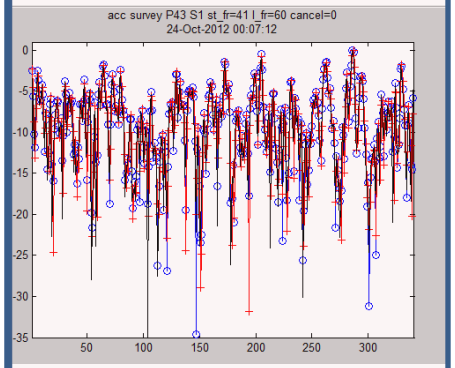
Stationary position, suburban, PIC

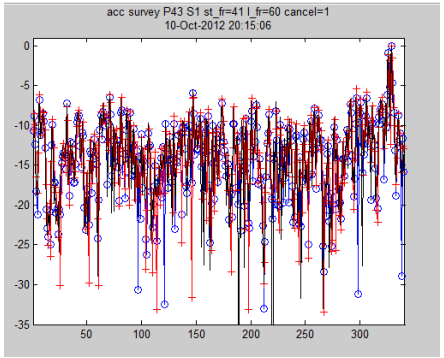
before

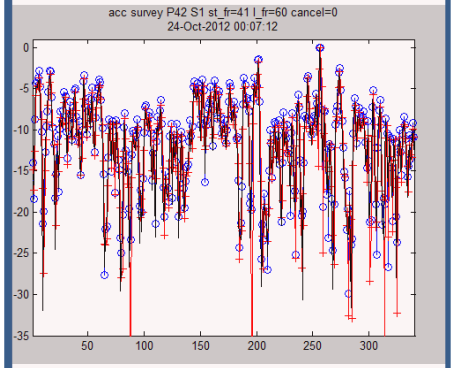
after

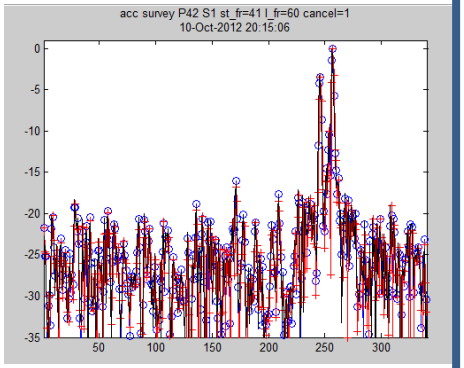




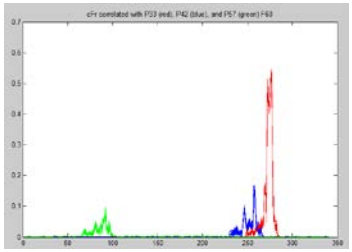


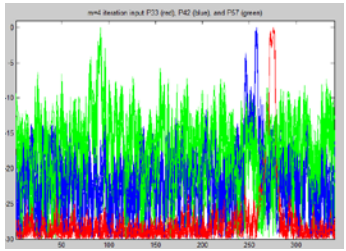






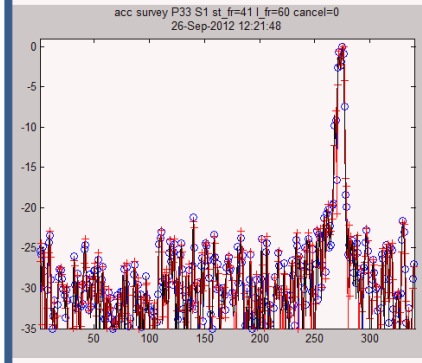
Grotto_14_33 ’67 P33 & P42 & P57

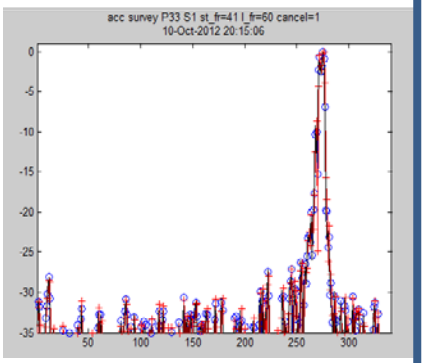




before

after





FIELD PERFORMANCE TESTS(3)

Actual drive test, suburban

test_2014_11_21_2667_1

P65 (simple mode)

P65 (JD)

FIELD PERFORMANCE TESTS(4)

Actual drive test, suburban

test_2014_11_21_2667_1

P74 (simple mode)

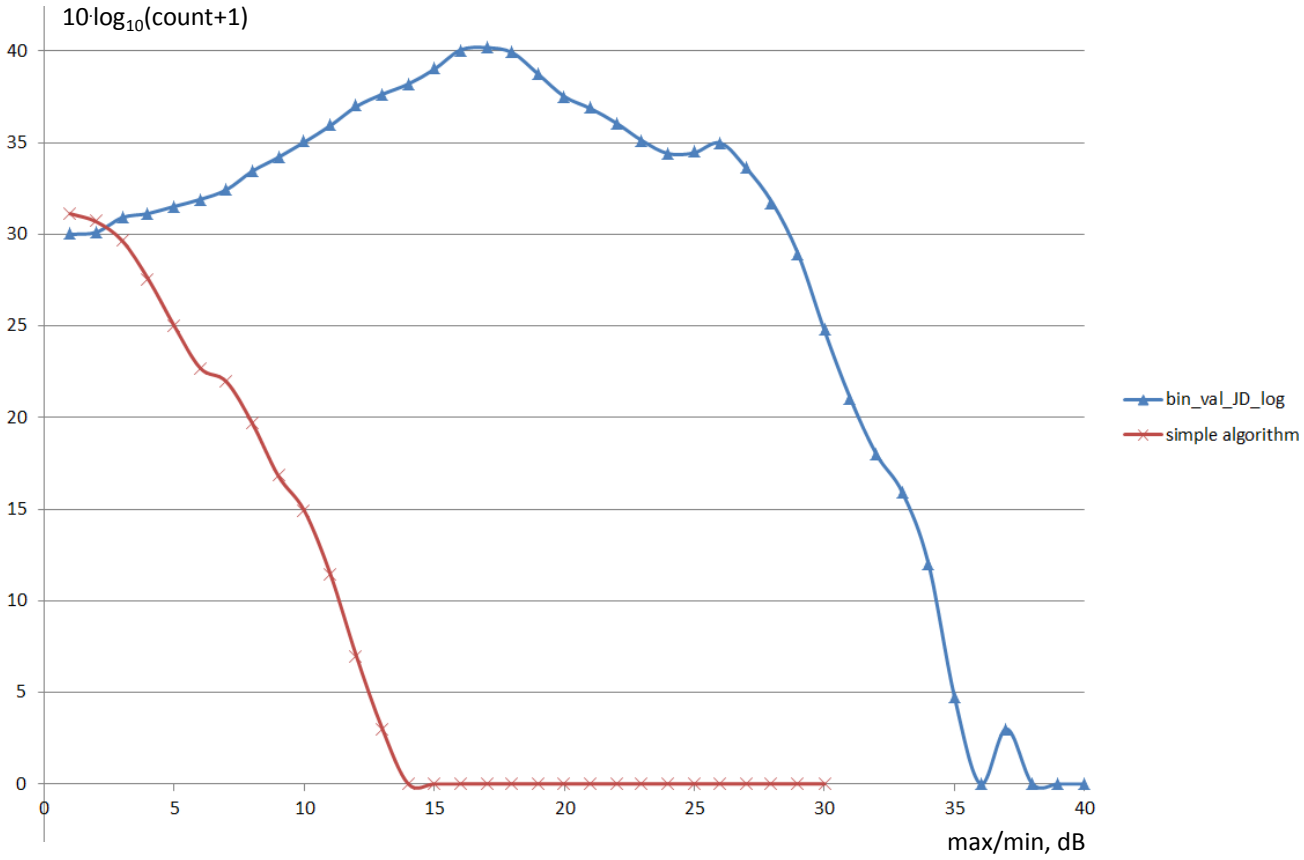
P74 (JD)

FIELD PERFORMANCE TESTS(5)

Actual drive test, suburban

test_2014_11_21_2667_1

Level histograms: max and min detected level difference-per-frame distribution (log scales both axes)



CONCLUSION

Wavenetix is a private T&M company

Wavenetix offers technologies and services for wireless testing and is looking for partnerships

Incorporated July 2010

Headquartered in Virginia

Products and services: systems and tools for the measurement and modeling of 4G wireless wideband MIMO propagation channels, e.g. WCDMA, WiMAX, TD-SCDMA, LTE, LTE-A, TD-LTE

Targeted markets:

- Device and network test and test equipment providers
- Wireless operators and network providers

Thank you!

Q & A