PARALLEL EVENT DETECTION IN SENSOR DATA

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CSE 633

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University at Buffalo The State University of New York

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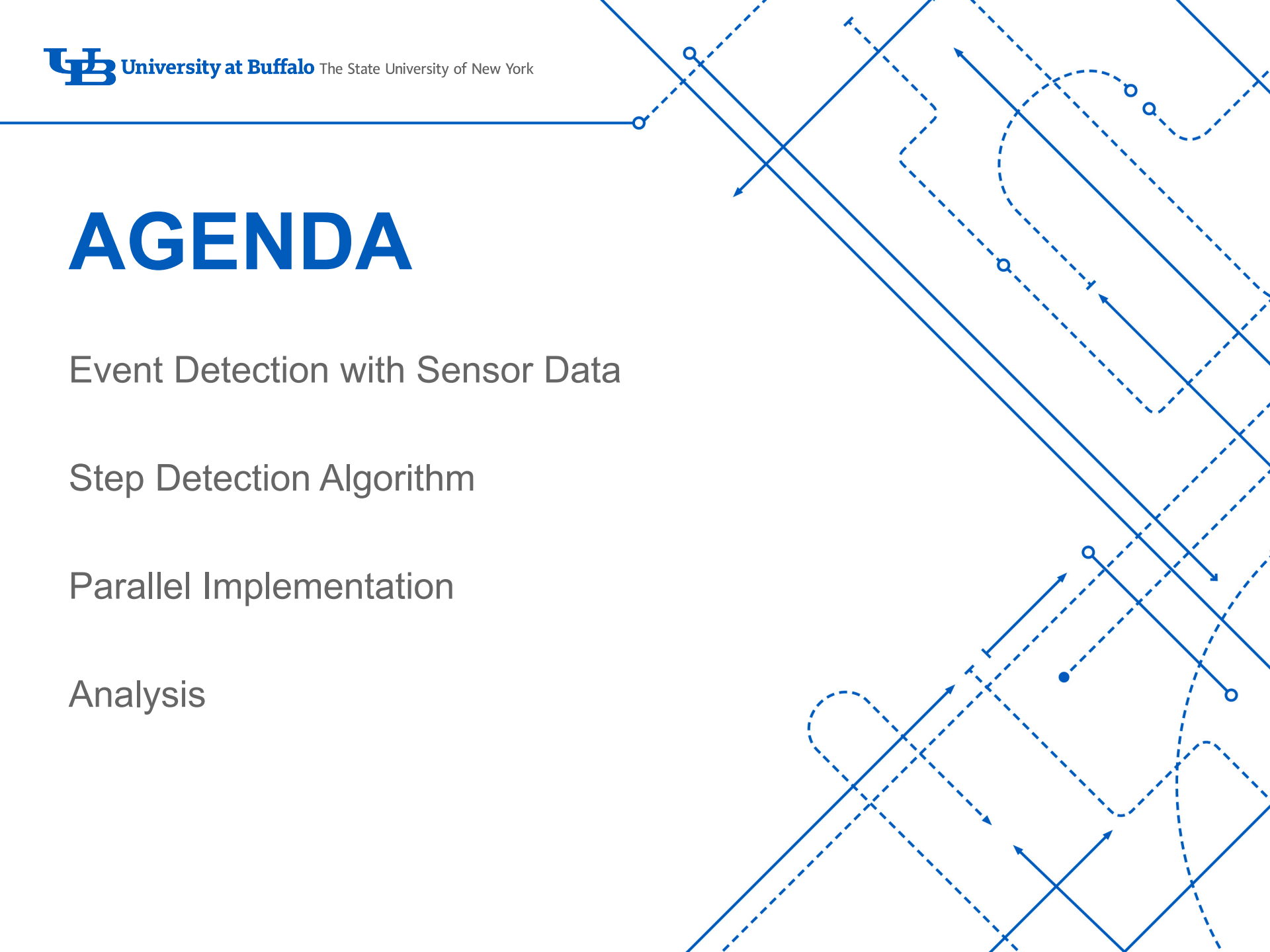
AGENDA

Event Detection with Sensor Data

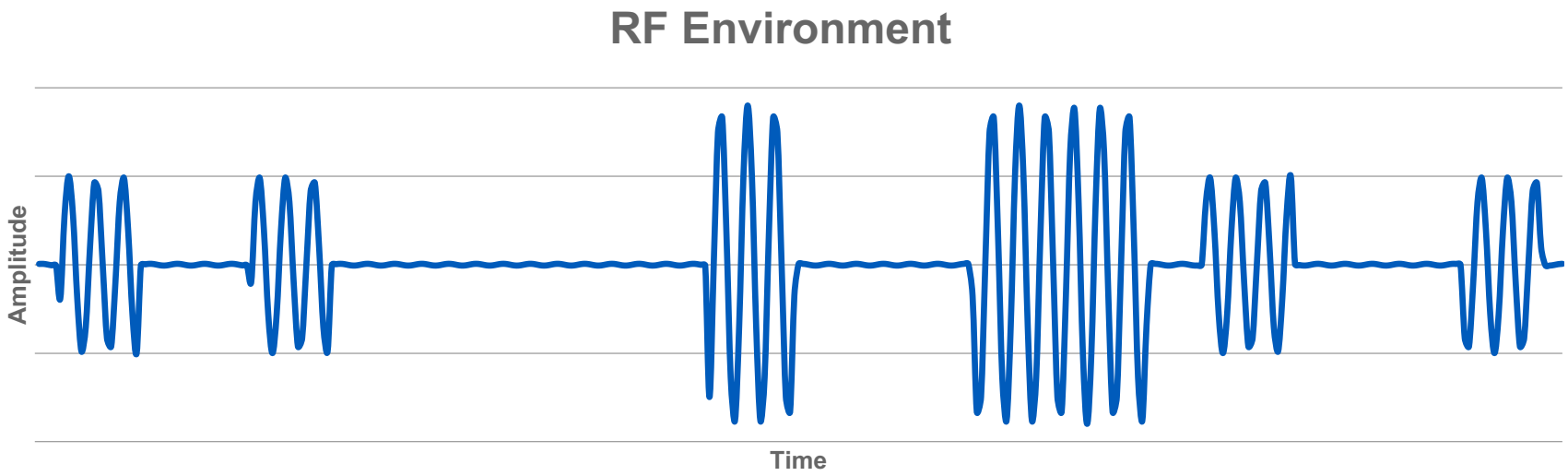
Step Detection Algorithm

Parallel Implementation

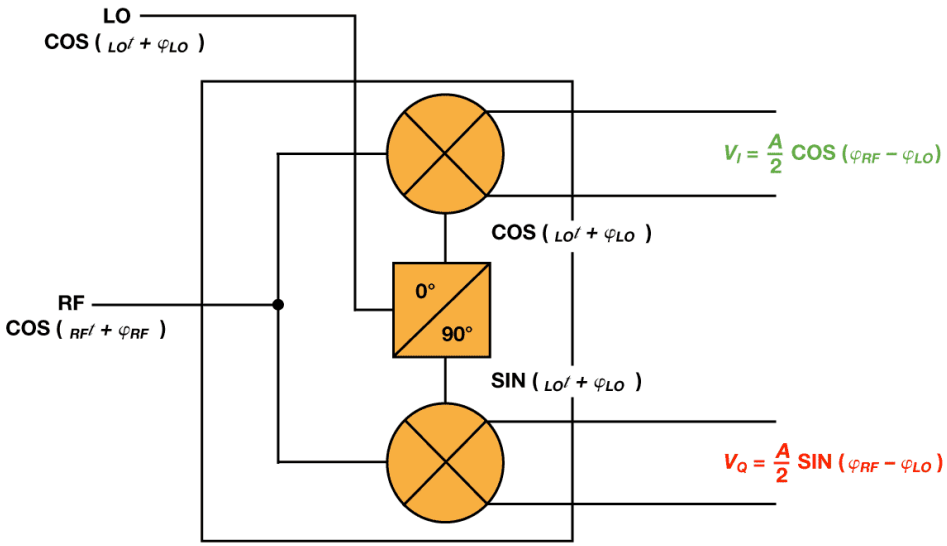
Analysis

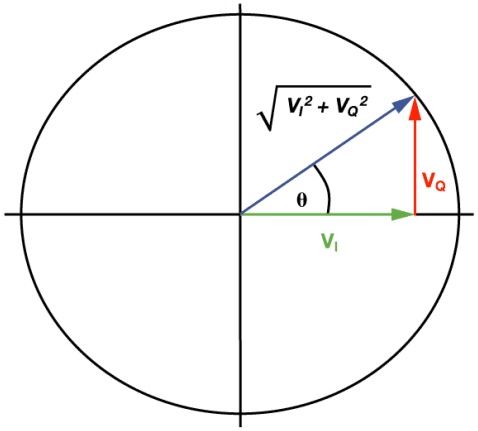


Radio Frequency Signals



In-phase and Quadrature Sampling





$$I = A\cos(\omega_{RF}t + \varphi_{RF}) \times \cos(\omega_{LO}t + \varphi_{LO}) = \frac{A}{2}\left[\cos(\omega_{RF}t - \omega_{LO}t + \varphi_{RF} - \varphi_{LO}) + \cos(\omega_{RF}t + \omega_{LO}t + \varphi_{RF} + \varphi_{LO}\right]$$

$$V_I = \frac{A}{2}\left[\cos(\varphi_{RF} - \varphi_{LO})\right]$$

Let $\omega_{RF} = \omega_{LO}$ difference term at dc

Sum term gets filtered

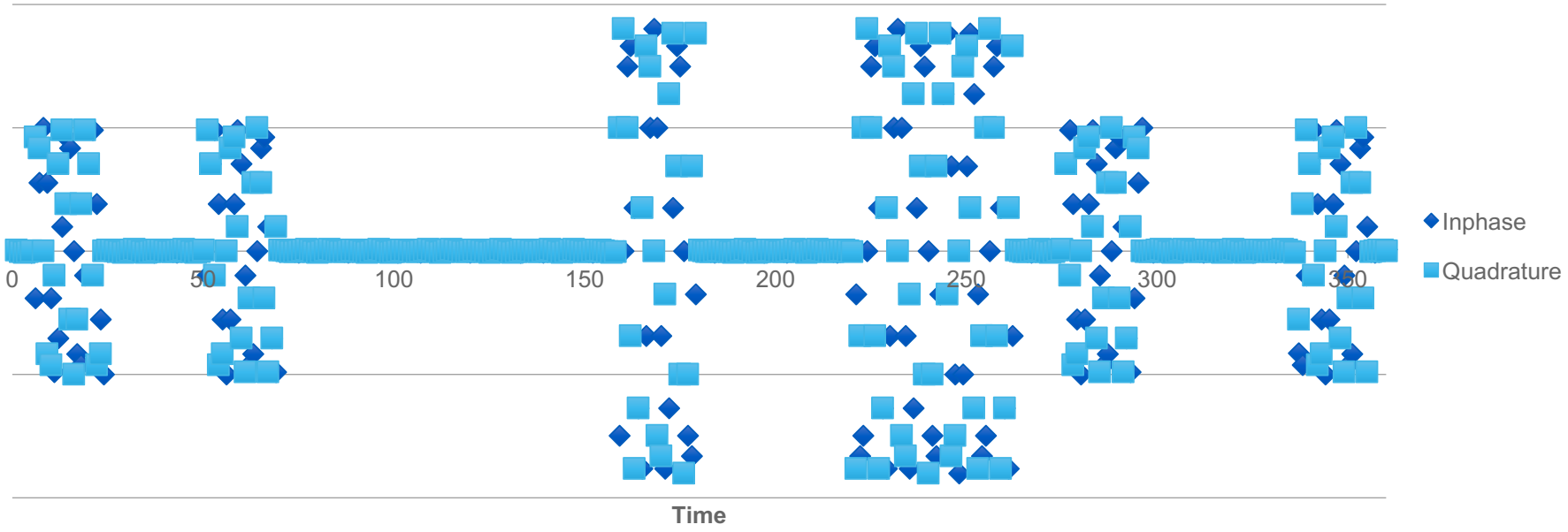
$$Q = A\cos(\omega_{RF}t + \varphi_{RF}) \times \sin(\omega_{LO}t + \varphi_{LO}) = \frac{A}{2}\left[\sin(\omega_{RF}t - \omega_{LO}t + \varphi_{RF} - \varphi_{LO}) + \sin(\omega_{RF}t + \omega_{LO}t + \varphi_{RF} + \varphi_{LO}\right]$$

$$V_Q = \frac{A}{2}\left[\sin(\varphi_{RF} - \varphi_{LO})\right]$$

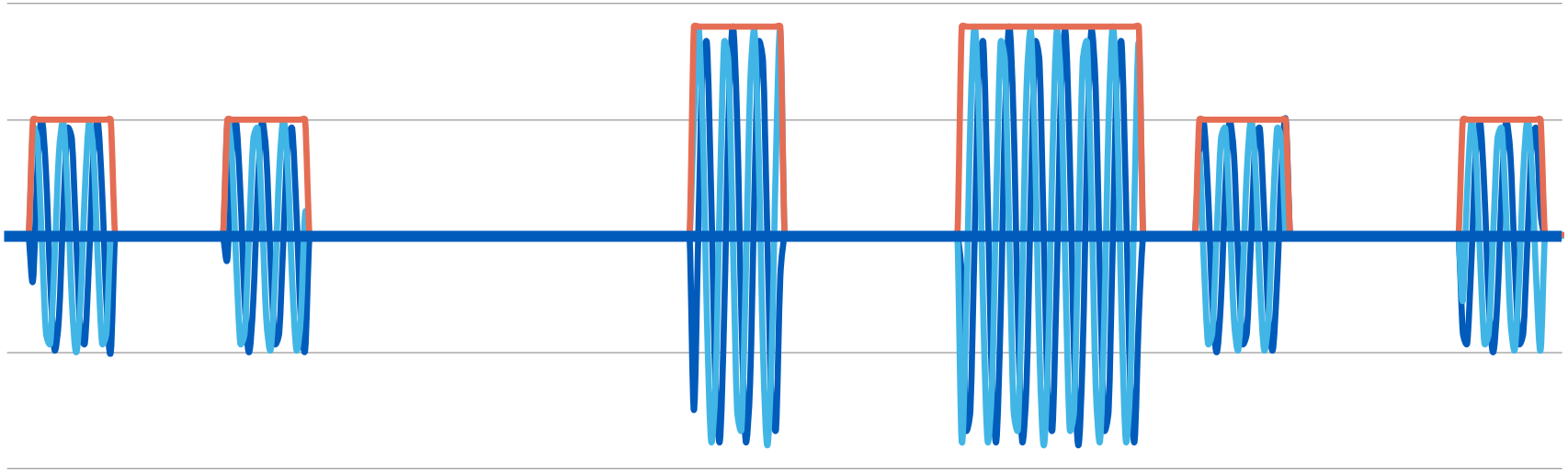
Let $\omega_{RF} = \omega_{LO}$ difference term at dc

Sum term gets filtered

Digitized Environmental Data



In-phase and Quadrature Analysis



Serial Step Detection Algorithm

Input: I_Data<NUM>, Q_Data<NMU>, Threshold
Output: Start_Points<INDEX>, End_Points<INDEX>

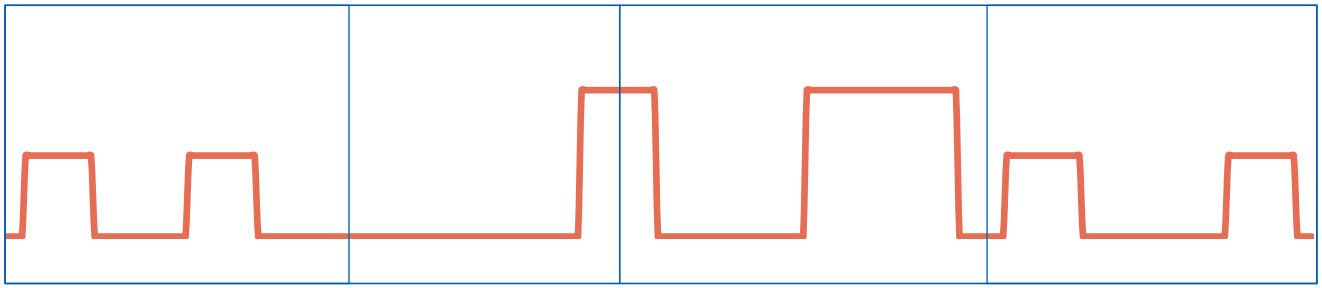
Boolean above = false

For index[start:stop]
    amplitude_sq = I_DATA[index]^2 + Q_DATA[INDEX]^2
    if (amplitude_sq > threshold^2 && !above) {
        Start_Points.pushback(index)
        above = true
    }
    else if(amplitude_sq < threshold^2 && above) {
        Stop_Points.pushback(index)
        above = false
    }

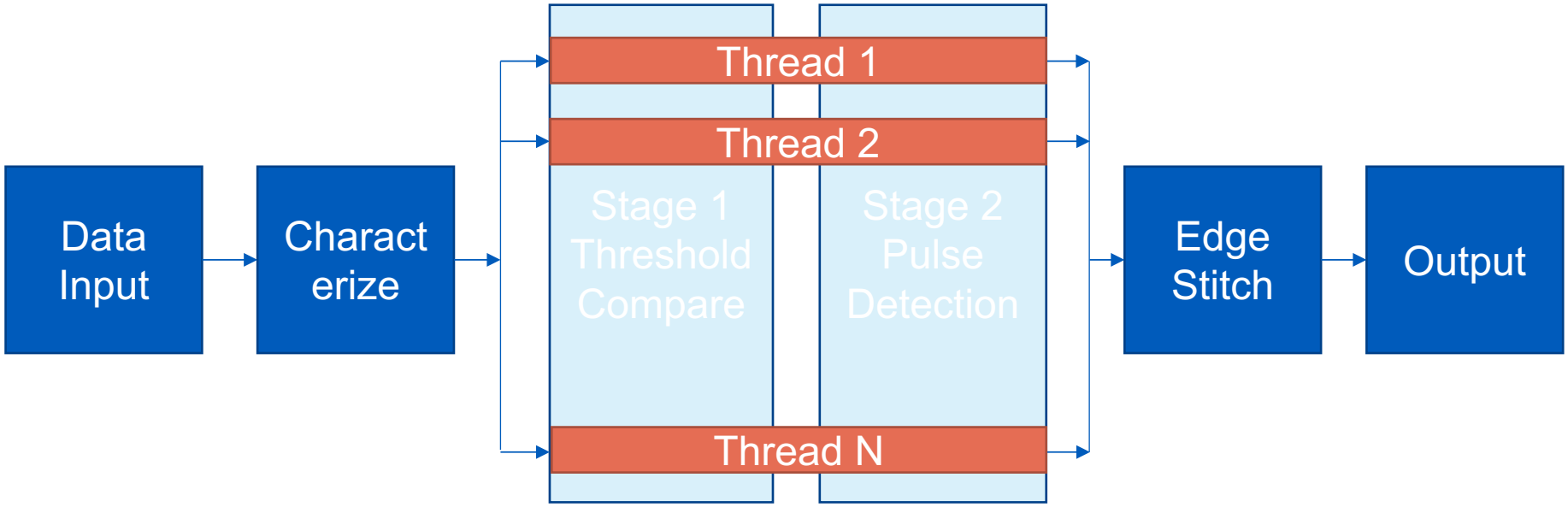
Parallel Algorithm

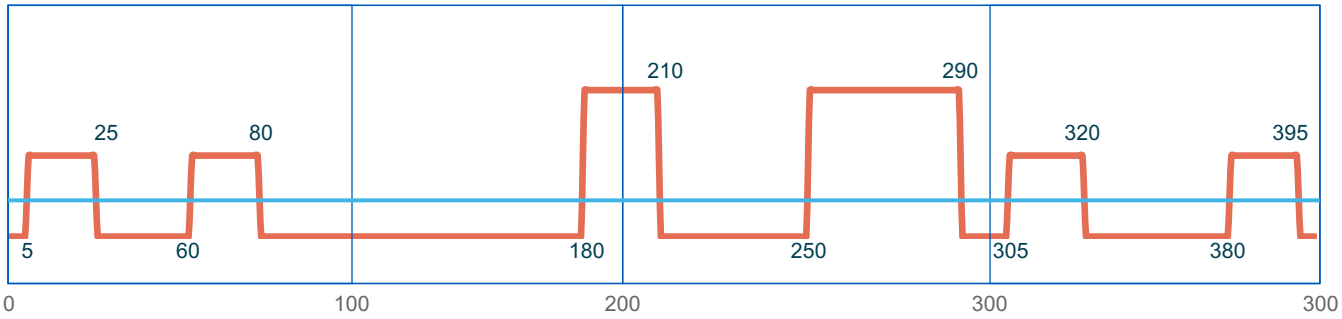
Divide and Conquer

- Easy split
  - Divide data amongst N processors
- Stage 1 in Parallel
  - Determine if amplitude is above threshold
- Stage 2 in Parallel
  - Identify edges
- Combine
  - Merge vectors
  - Handle pulse overlap



Parallel Algorithm





Parallel Implementation

C++ Application

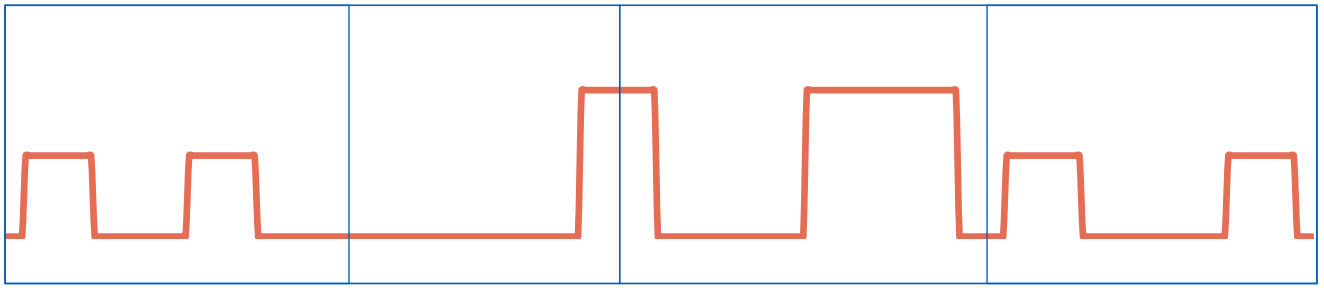
- Data generation utility
- Framework for stage based signal processing
- Processing algorithms in discrete kernels

OpenMP

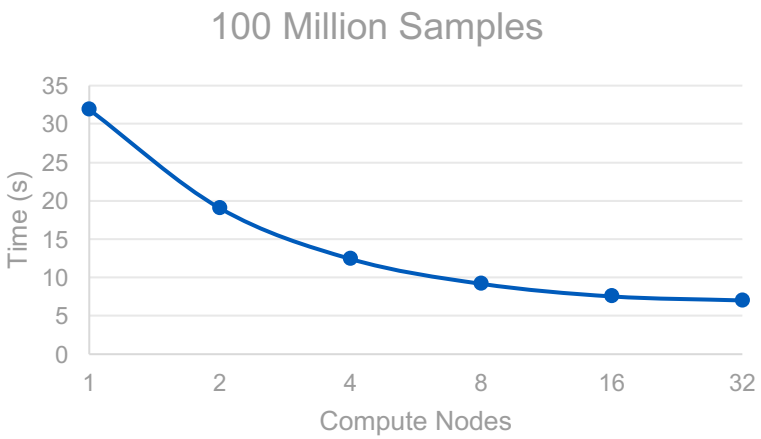
- omp parallel for
- omp_set_num_threads()

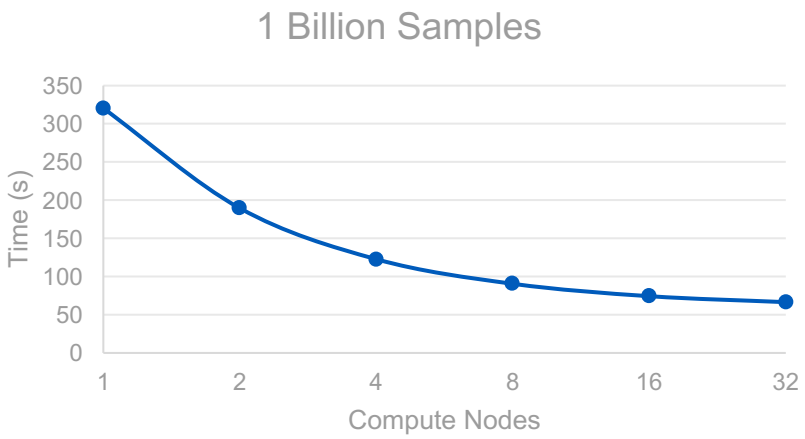
Large Memory Cluster

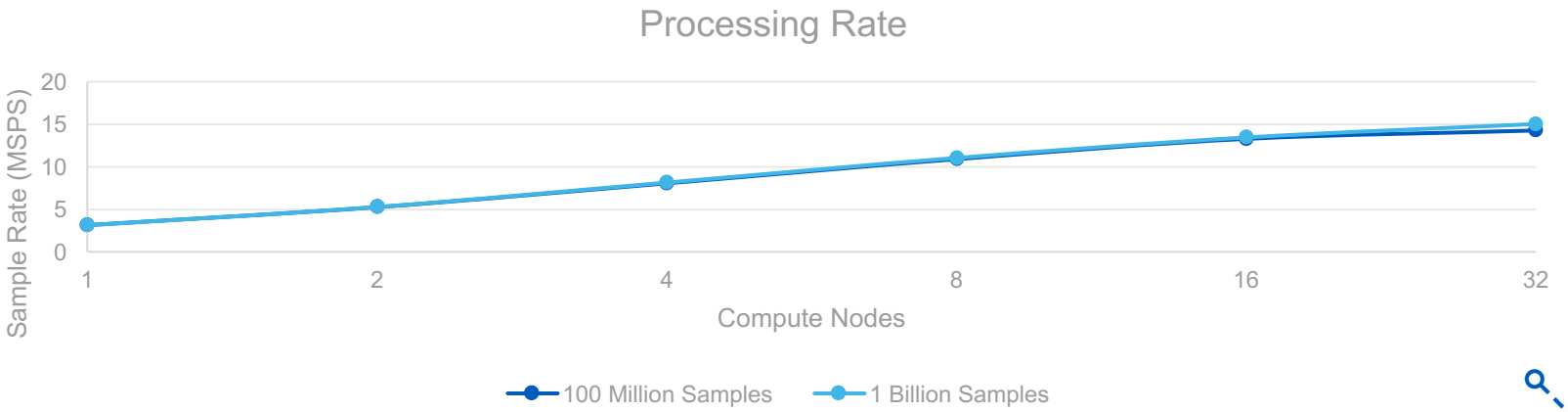
- 32 Core Machine
- 256+ GB RAM



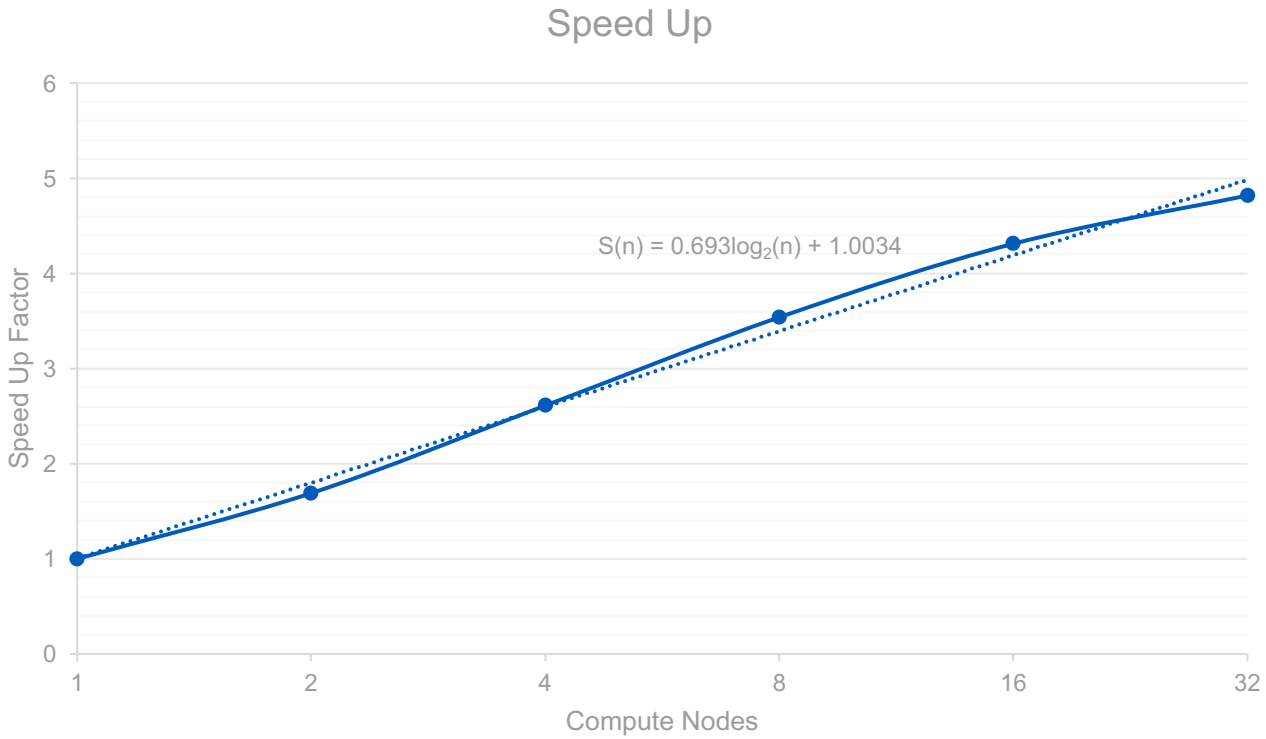
Runtime Analysis







Runtime Analysis



Conclusions

Successes

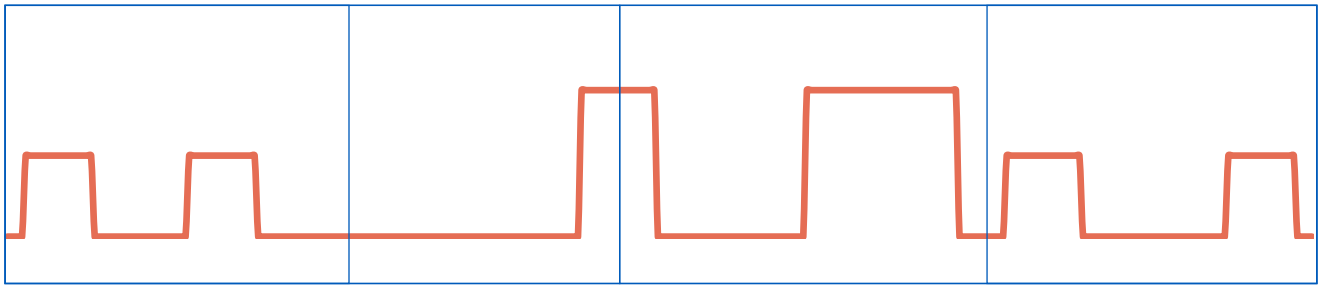
- Linear Speed Up achieved
  - 4x speed up on 8 core machine
- Reduce user facing processing time by utilizing idle cores
- Creation of parallelizable Digital Environment Processing Framework

Room for improvement

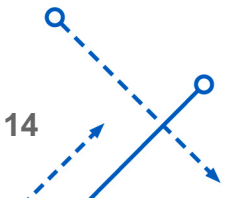
- Optimize processing at stage level

Future Work

- Add more DSP stages to processing framework
- Implement GPGPU kernels



Questions?



References

IQ Receiver Diagram
http://www.analog.com/en/analog-dialogue/articles/rf-to-bits-solution.html

IQ Sampling
http://www.ieee.li/pdf/essay/quadrature_signals.pdf

OpenMP and Slurm Support
https://ubccr.freshdesk.com/support/solutions/articles/13000026245-tutorials-and-training-documents

Runtime Data

Samples/Cores	1	2	4	8	16	32
1.00E+07	2.956138	1.839053	1.245545	0.953884	0.825309	0.841648
1.00E+08	31.872928	19.02572	12.410948	9.170127	7.524059	7.004921
1.00E+09	320.359305	189.516166	122.697726	90.522017	74.30246	66.487053