Performance Evaluation & SON Aspects of Vertical Sectorisation in a Realistic LTE Network Environment

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Outline

- Introduction
- Vertical Sectorisation
- Modelling & Simulation Scenarios
- Numerical Results & Analysis
- SON Function Analytical Model
- SON Function Calibration
- Conclusions & Further Steps

Introduction

- Motivation
  - Increasing traffic demand in mobile networks
  - New systems & features for higher network capacity & improved performance

Active Antenna Systems (AAS)

- Improved network performance
- Reduced costs
- Long-term sustainability

Vertical Sectorisation (VS)

- Increased network capacity
- Improved UE performance

Self-Organizing Networks (SON)

- Intelligent networks
- Multi-layer & multi-RAT functionality
- High degree of flexibility
- High degree of adaptability
  - Spatial traffic variations
  - Temporal traffic variations

How to combine VS with SON to maximize gains and optimize performance?

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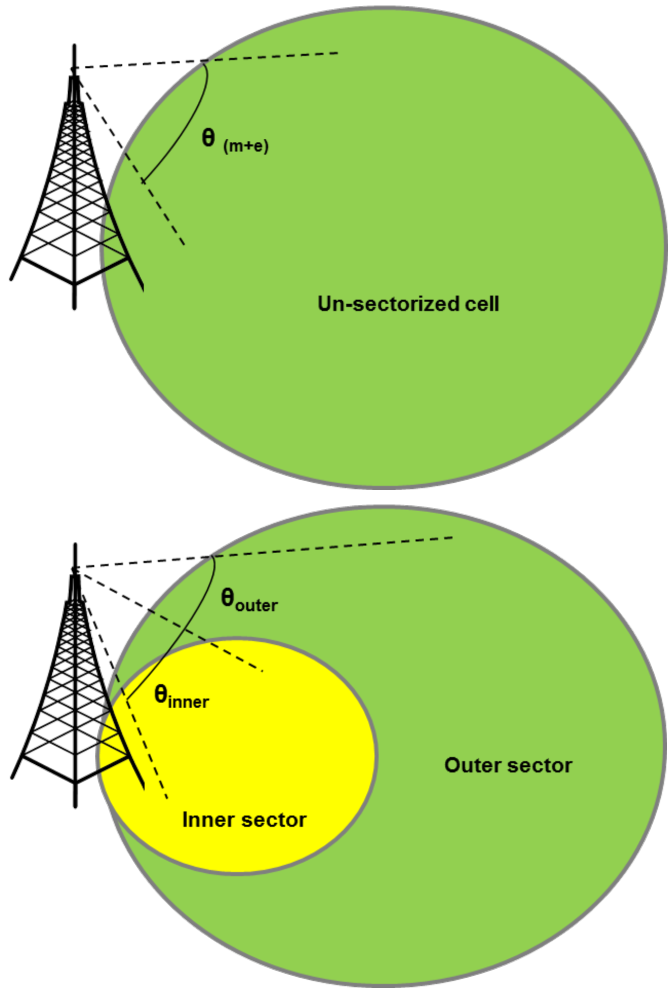
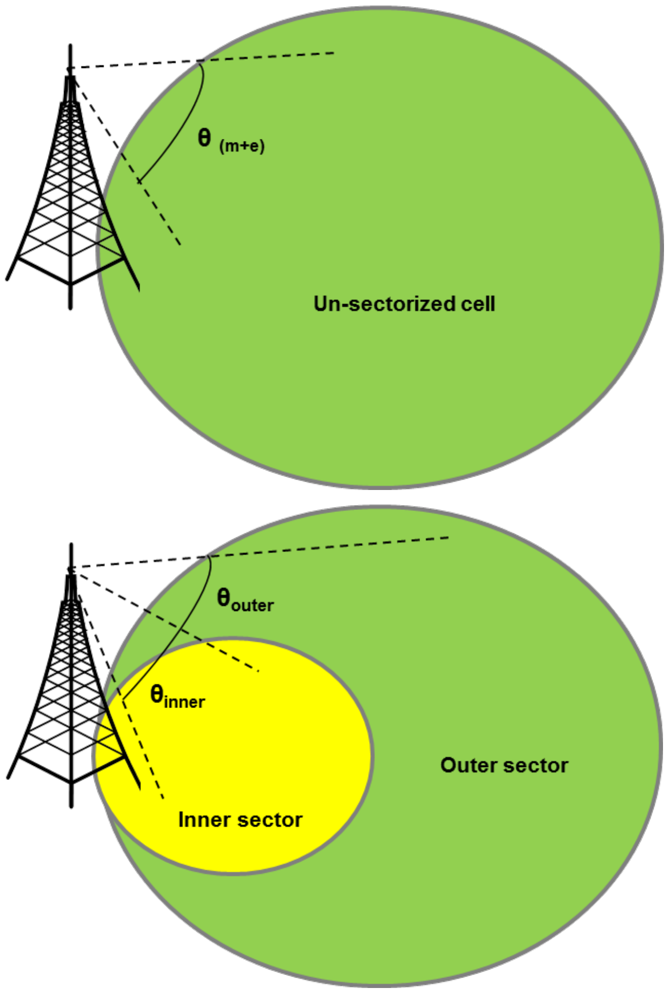
Vertical Sectorisation

- VS is performed by splitting the antenna beam serving one cell, into two beams with different electrical tilts – θ_e (split in the vertical plane)
- The mechanical tilt of the antenna remains the same
- The former cell is split into two new cells / sectors serving different areas
- The two sectors have their own physical cell IDs
- Full reuse of the available spectral resources
- Sharing of the total transmit power available for the cell ($P_{total} = P_{inner} + P_{outer}$)



Vertical Sectorisation

- Pros
  - Spatial reuse of resources
  - Reduced inter-cell interference (reduced Tx power)
  - Focused beam on high traffic demand area (increased SINR)
- Cons
  - Reduced Tx power per sector
  - Increased inter-cell interference (additional cell)



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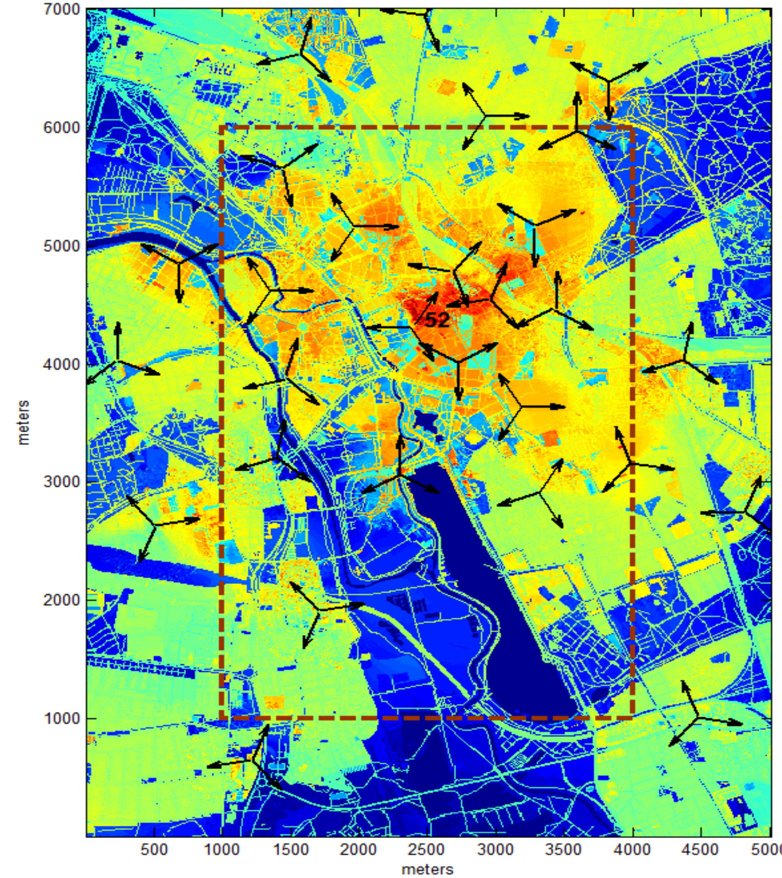
Modelling & Simulation Scenarios

- Realistic LTE network (Hannover, Germany)
- Advanced AAS model based on Kathrein 3GPP contributions
- Realistic in/outdoor ray tracing propagation model (including 3D building data)
- Realistic traffic intensity maps

Attribute	Value
Area size	5x7 km^2 (3x5 km^2)
Nº sites / cells	63 (36) / 84 (51)
Frequency band	1800 MHz
Bandwidth	20 MHz
Cell max Tx power	40 W (46 dBm)
Antenna gain	18 dBi
Antenna mech. tilt	4º
Session file size	16 Mb
Scheduling	Fair sharing
Link adaptation	Modified Shannon curve



Modelling & Simulation Scenarios

- Highly loaded scenario (Average cell load 42% - centre of Hannover 60% - 85%)
- Simulation of multiple scenarios for different VS parameters values
- Electrical tilts are on top of 4º mechanical tilt
- θ^{e}_{outer} was kept at 0º to maintain the coverage level

	Inner Sector	Outer Sector
Electrical downtilt	$\theta^{e}_{inner} \in \{6^{o}, 8^{o}, 10^{o}\}$	$\theta^{e}_{outer} = 0^{o}$
Power split	$P_{inner} \in \{0.2, 0.5, 0.8\} \times P_{total}$	$P_{outer} = P_{total} - P_{inner}$

- VS status
  - VS always ON
  - VS always OFF
  - VS controlled by SON function
- VS level
  - Entire network
  - Single cell

- KPIs
  - Average & 10th user throughput
  - Coverage ratio
  - Resource utilization
  - Nº users served per cell

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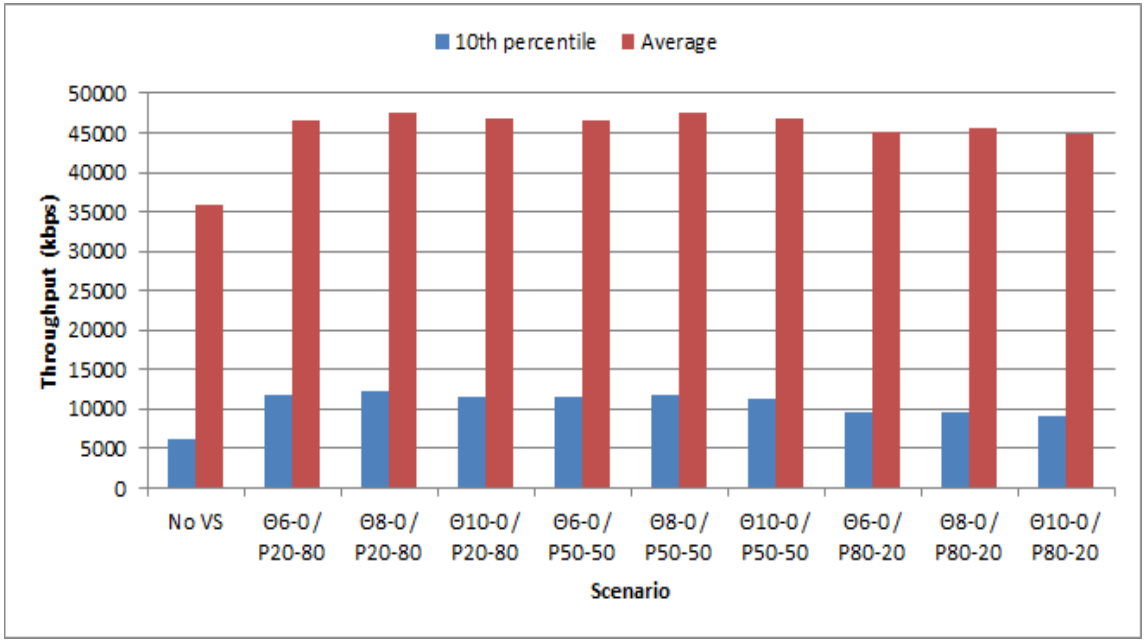
Numerical Results & Analysis

- Network-wide VS
  - For a highly loaded scenario VS is always beneficial for the network
  - Almost all of the cells present gains in performance
  - Average gains of up to 33% for average user throughput and 95% for 10^{th} percentile
  - Best performance for tilts θ8-0 and power split depends on KPI
    - P50-50 for average user throughput
    - P20-80 for 10^{th} percentile user throughput

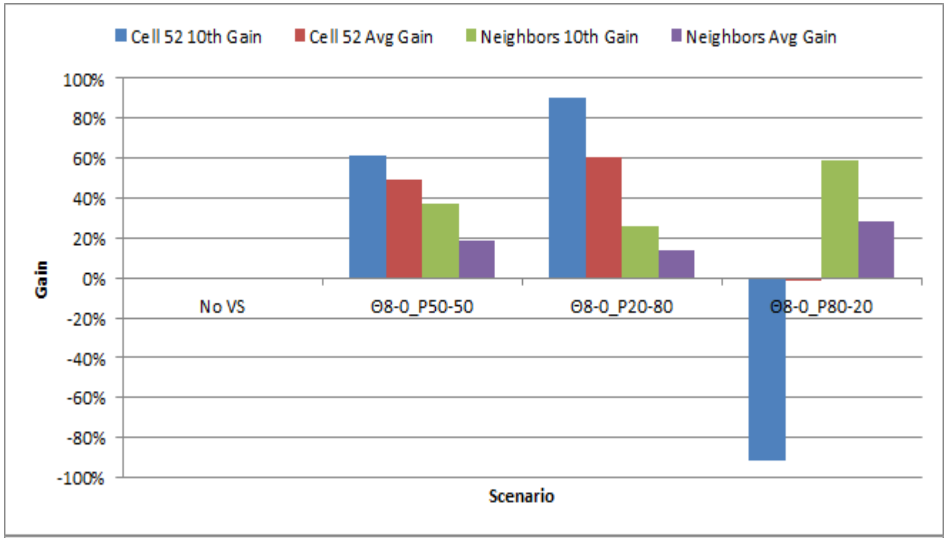
- Power split matching to traffic distribution is very important

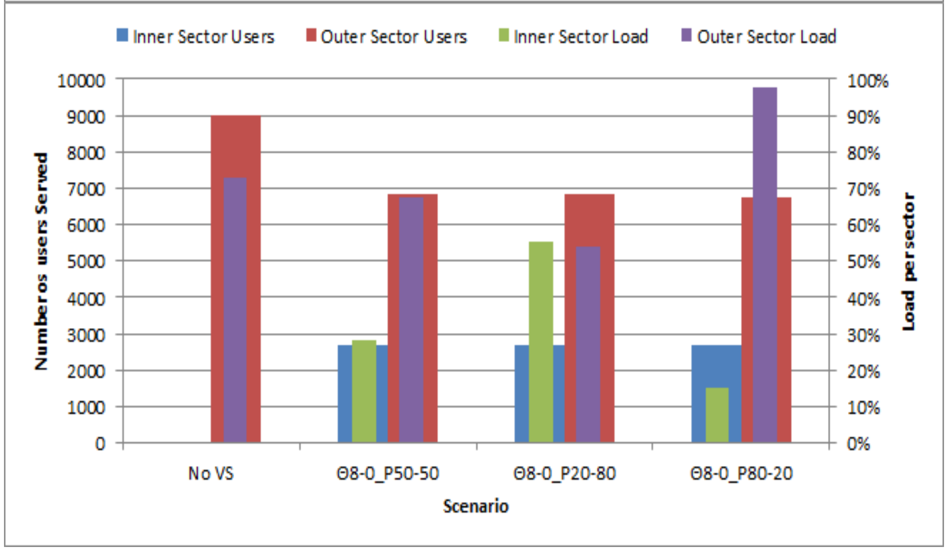
- Where does the gain come from? Resource re-use? Change in interference?



Numerical Results & Analysis

- Single cell VS
  - When matching of power split is close to traffic distribution, the performance of the VS cell improves
  - Neighbouring cells performance always improves due to decreased inter-cell interference (highly dependent of P_{outer})
  - Majority of users are served by the outer sector (larger footprint)
  - Different power splits have great effect on sector resource utilization
- Need for a SON function
  - Activation / de-activation of VS
  - Selection of appropriate cells for VS
  - Optimization of VS parameters





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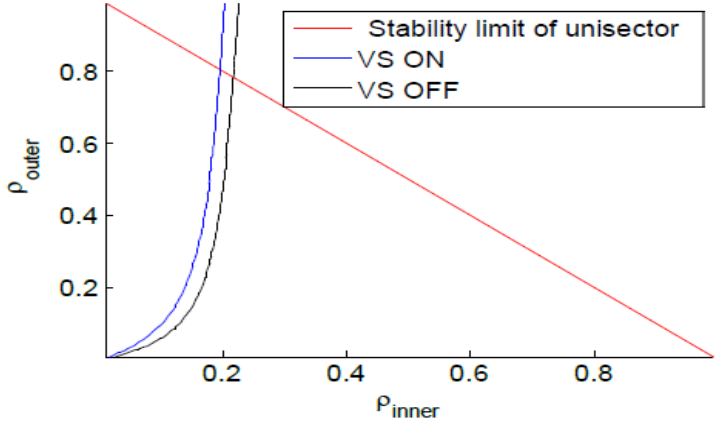
SON Function Analytical Model

- Design of a VS controller for VS activation / de-activation on a per cell basis
  - Decision based on load estimation of inner & outer sectors
  - Goal: Maximize Mean User Throughput (MUT) within the cell

- Two decision boundaries
  - Activate when VS is OFF (based on estimated load)
  - De-activate when VS is ON (based on actual loads)

- Assumptions
  - Tri-sector site surrounded by six interfering eNBs
  - Worst case scenario = full interference from all eNBs

- Maximize MUT



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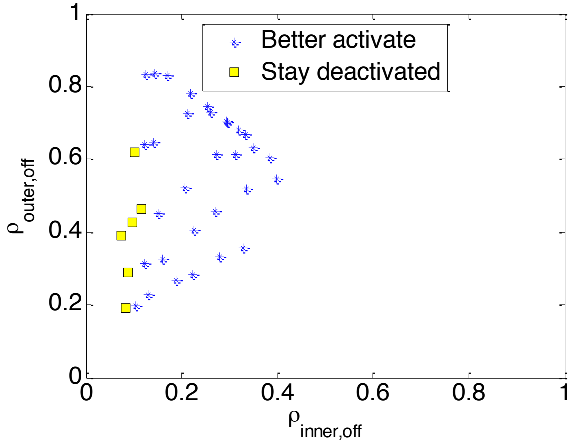
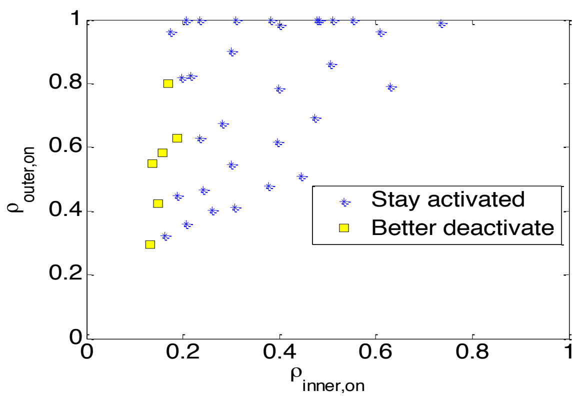
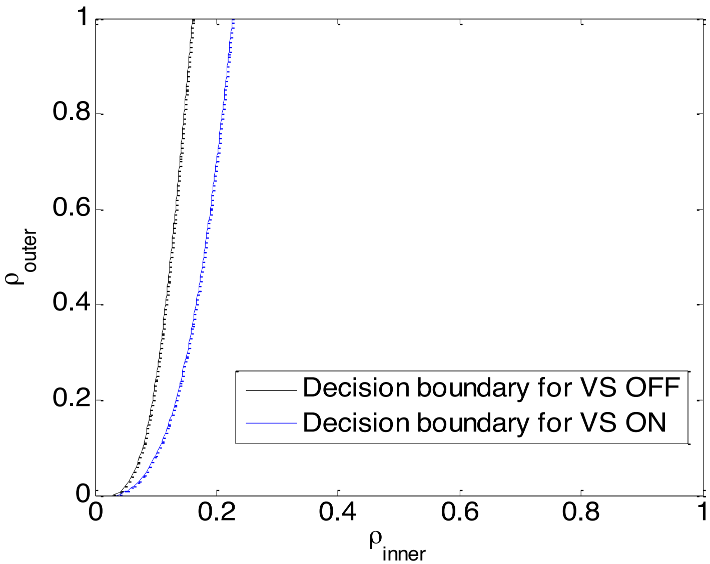
SON Function Calibration

- SON model adjustment using the realistic LTE system level simulator
  - Variable loading
  - Evaluate MUT in cases of VS ON & VS OFF
  - Find decision boundaries (logistic regression fitting) by choosing action for maximum MUT

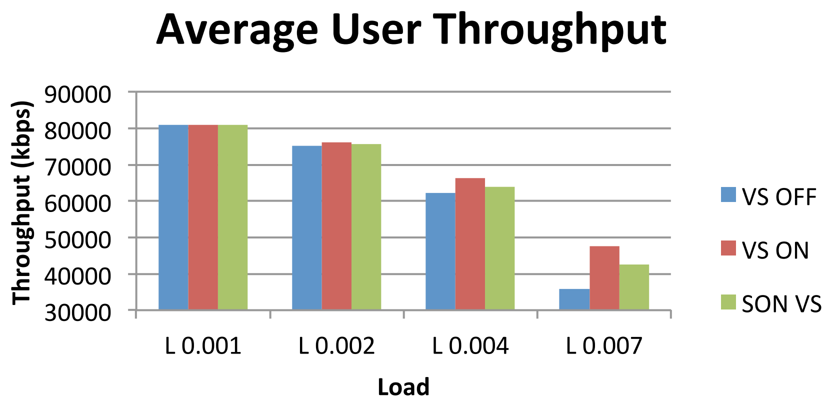


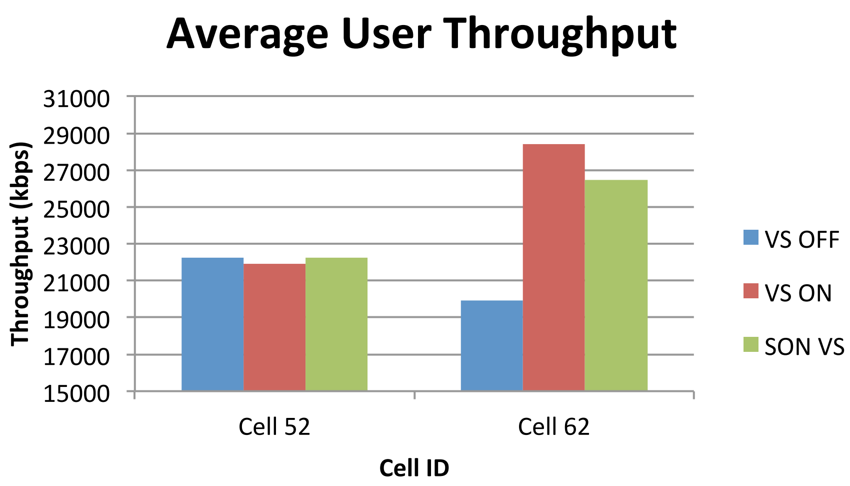


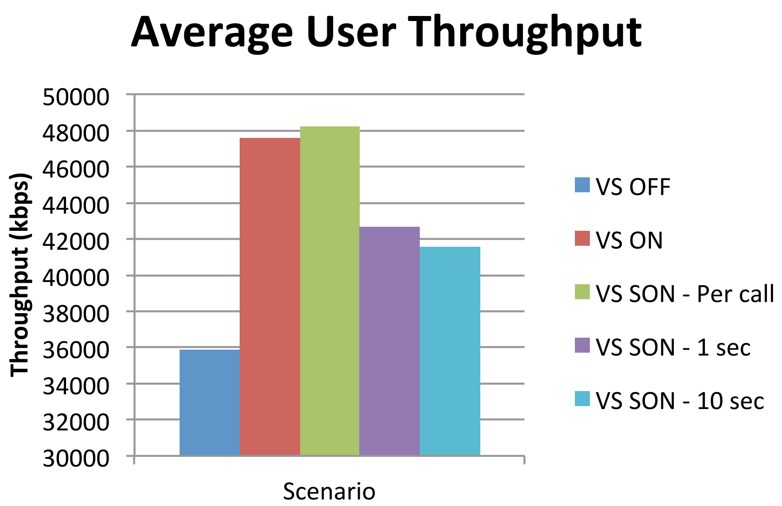


SON Function Calibration

- Performance of VS SON depends on multiple factors
  - Decision timing interval / macroscopic vs microscopic application
  - Cell characteristics
  - Load & traffic distribution
  - Inter-cell interference
  - Tilt & power settings







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Conclusions & Further Steps

- VS can offer significant gains which depend on
  - Cell load & traffic distribution
  - Interference conditions
  - VS parameters settings
- Need for a smart (de)activation rule & parameter optimization
- SON controller can offer improved performance of VS on a per cell basis
- SON controller performance is sensitive to multiple factors
- Next steps
  - Assess VS performance with respect to the cell's vertical angular spread
  - Inner & outer sector load estimation optimization
  - VS decision timing optimization
  - VS parameters optimization (tilt & power)

Thank you

Questions ?