Mobilitätsmodellbasierte Ressourcenmodellierung für Heterogenen Umgebungen

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Outline

- Model Application
- Mobility Models
- Studies on Hot Spot Visits / Cell Visits
- Studies on Hot-Spot Communications
- Conclusions

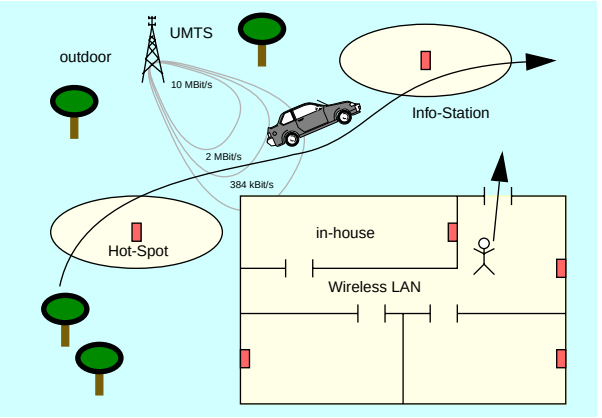
Model Application

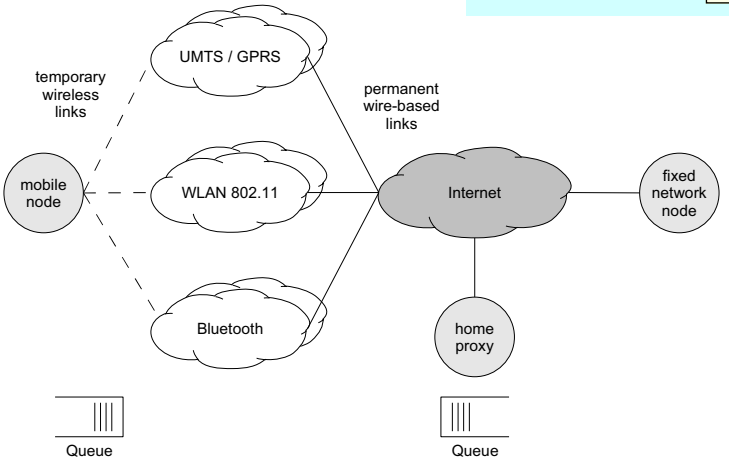
Communication Services

- **Adaptive applications**
- **Adaptive transport**
  - e.g. opportunistic scheduling

➥ **Need for**

- reference resource situations
- reference load situations

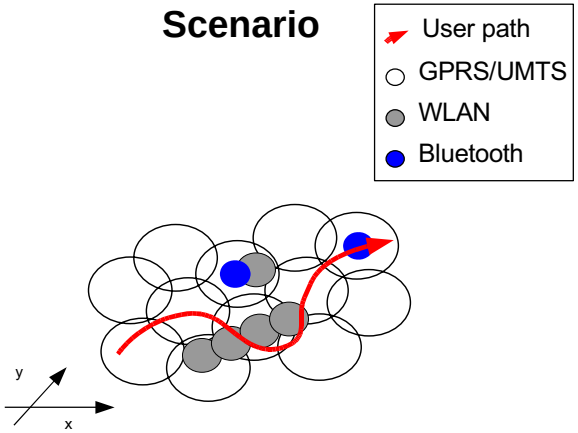




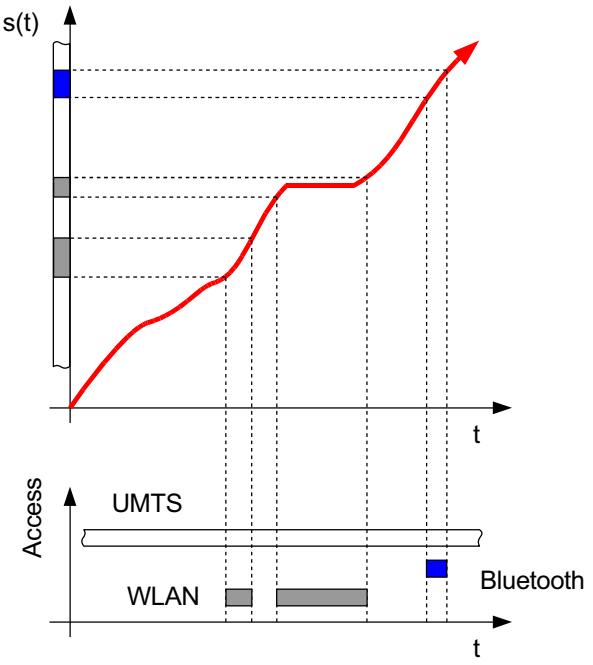
Model Application

Abstract View

Scenario



Resource Model



Simple Resource View

- **1 active radio interface (ABC)**
  $\gamma_{max} = \max(\gamma_i)$
- **Multiple active radio interfaces**
  $\gamma_{sum} = \sum \gamma_i$

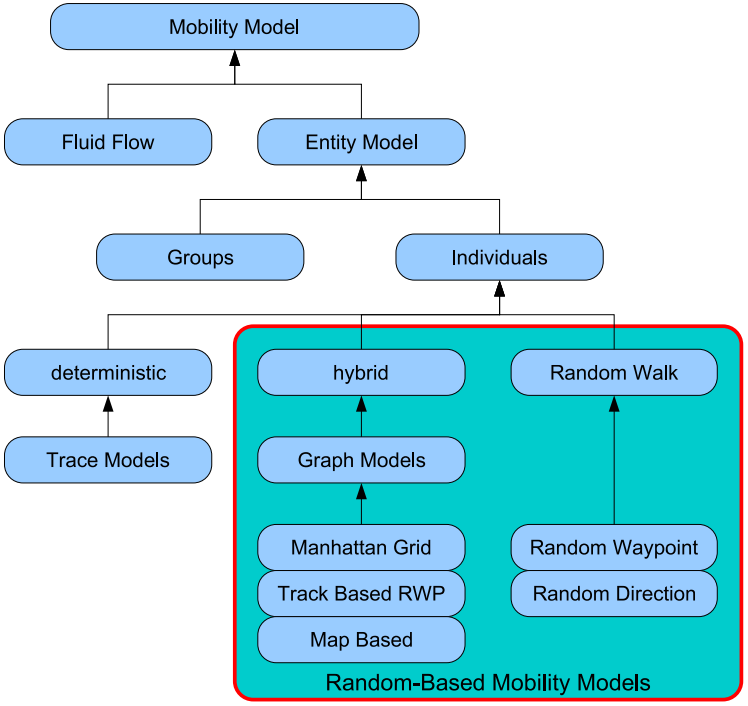
➥ **No multi-user view**

Simulation Requirements

- **stationarity**
- **being uncorrelated**
- **simple adjustment parameters**

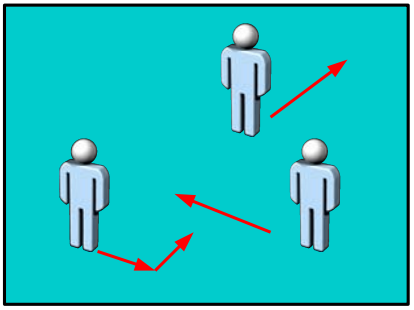
➥ **approach via topologies and mobility models**

Classification



from DA Neubauer: "Evaluierung und Parametrisierung von statistischen Nutzerbewegungsmodellen"

Entity Models



Parameter

- Geometry
- Border behaviour
- ...

Observation Values

- **Sojourn density**

$$\bar{\rho} = \frac{1}{T} \int_{t_1}^{t_1+T} \frac{n(t)}{A} dt$$

- **Movement vector sum**

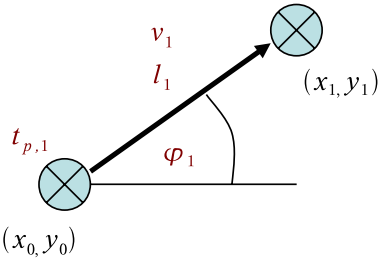
$$\bar{\phi} = \frac{1}{T} \int_{t_1}^{t_1+T} \frac{\vec{v}(t)}{A} dt$$

Observation on a Walk Area

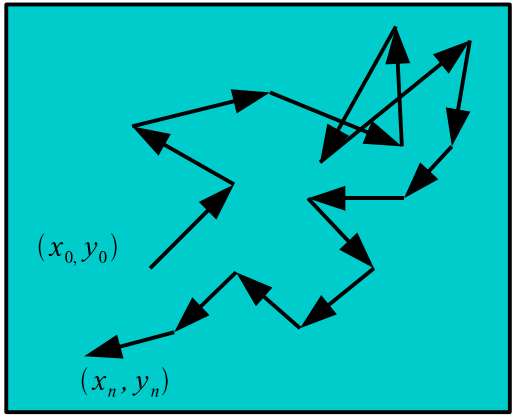
- **Evaluation based on a $U \times V$ grid to obtain**
  - ➥ Sojourn density distribution
  - ➥ Movement vector fields

Random Direction

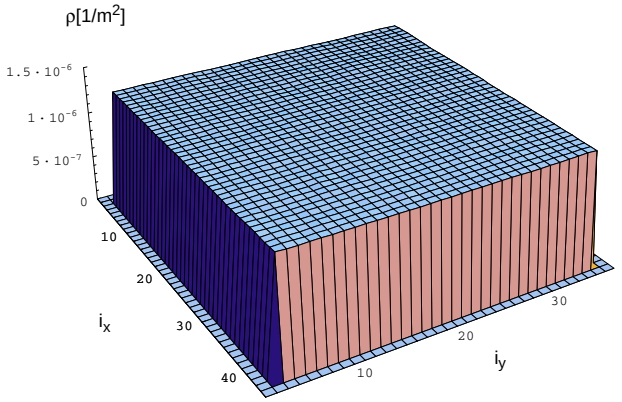
- **Choice of heading**
- **Random variables:** $t_{p,n}$, φ_n, l_n, v_n
- **Different variants in literature**



Trace

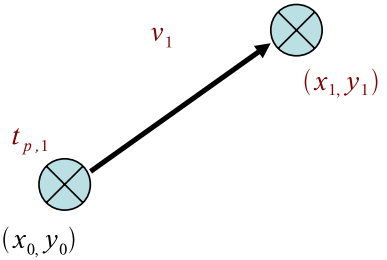


Sojourn Density Distribution



Random Waypoint

- **Choice of next waypoint**
- **Random variables:** $t_{p,n}$, $\vec{x}_n = (x_n, y_n)$, v_n



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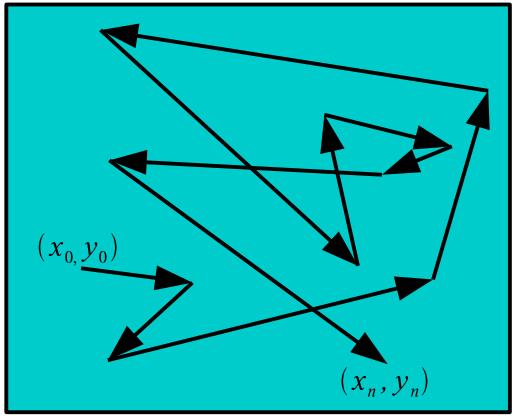
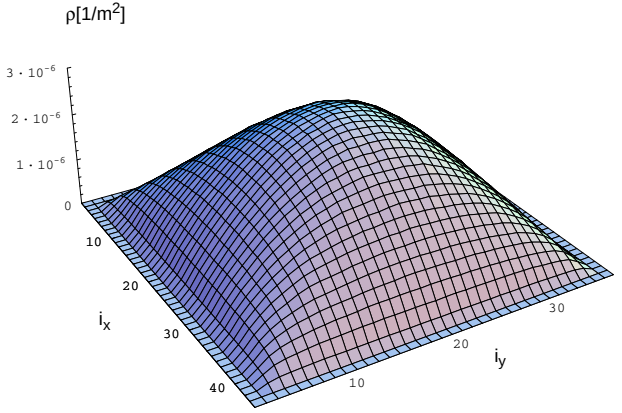
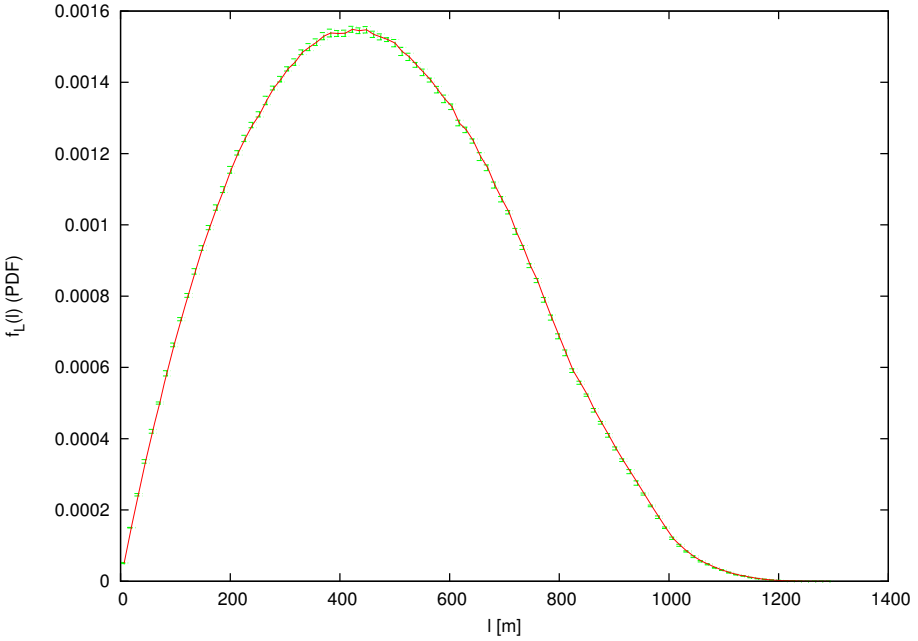


Sojourn Density Distribution

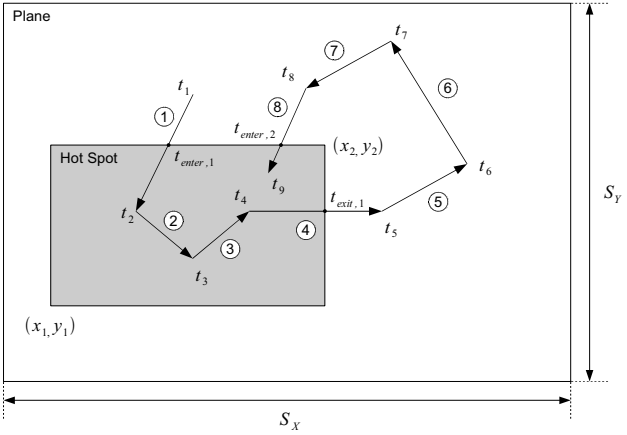


Random Waypoint

- **e. g. epoch length: Bettstetter, Hartenstein, Pérez-Costa**

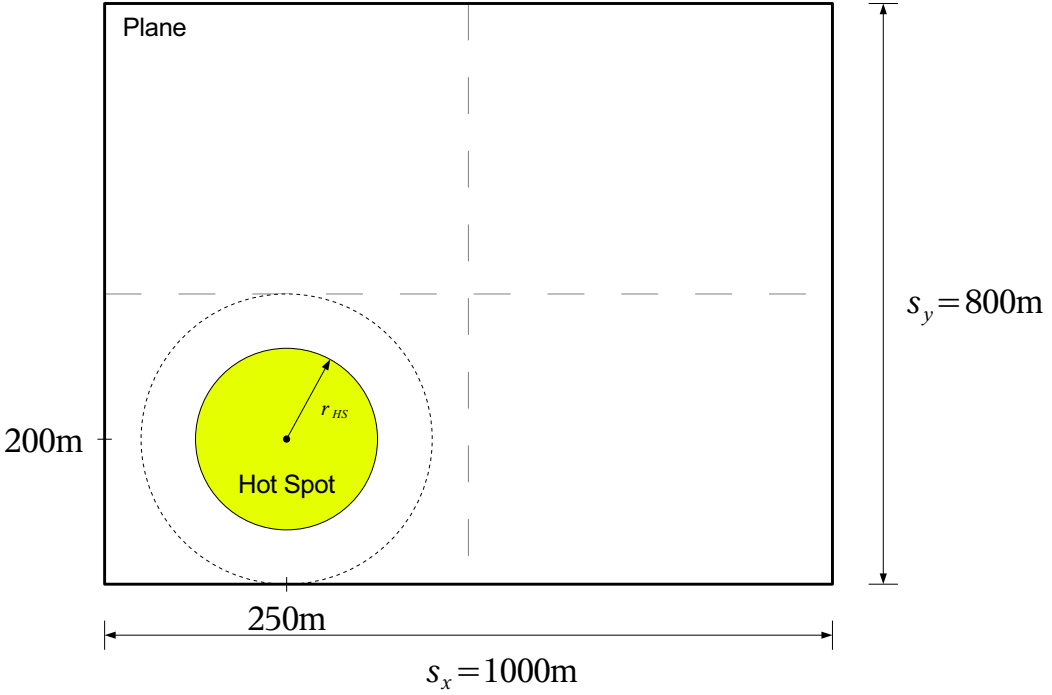


Hot Spot Visits



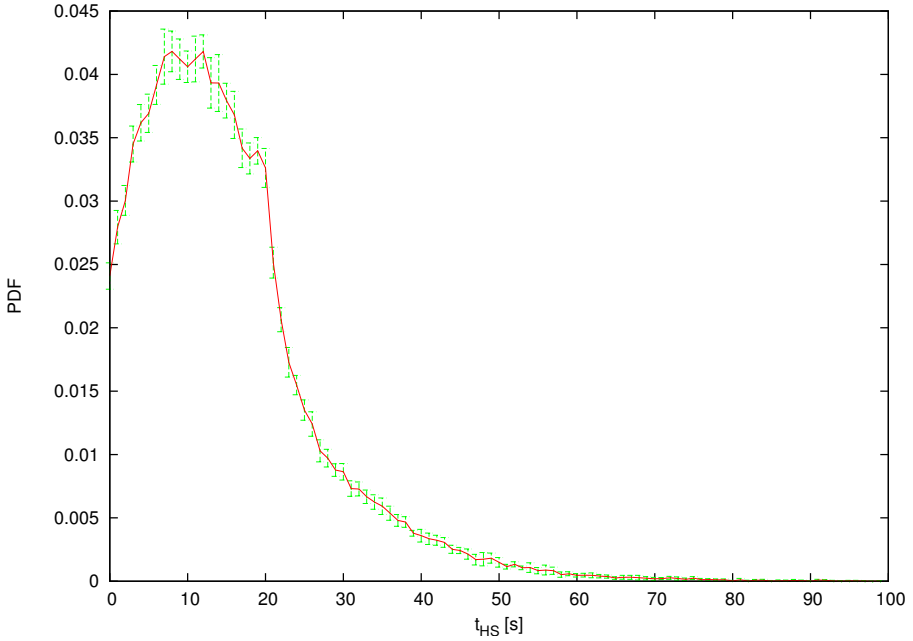
- **Visits**
  - epoch lengths
    on enter, on exit, intra, transit
  - visit walk length
  - visit time t_{HS}
- **Inter-visit times**
  - visit inter arrival time t_{IAT}
  - inter visit time

Simulation Scenario "Hot-Spot Size"



Dwell Time Density

- **Random Direction, Opposite Enter,** $l_{Segment} = 100m$, $v = 10\frac{m}{s}$ **hot-spot:** $\vec{p}_{HS} = (250\text{m}, 200\text{m})$, $r_{HS} = 100m$



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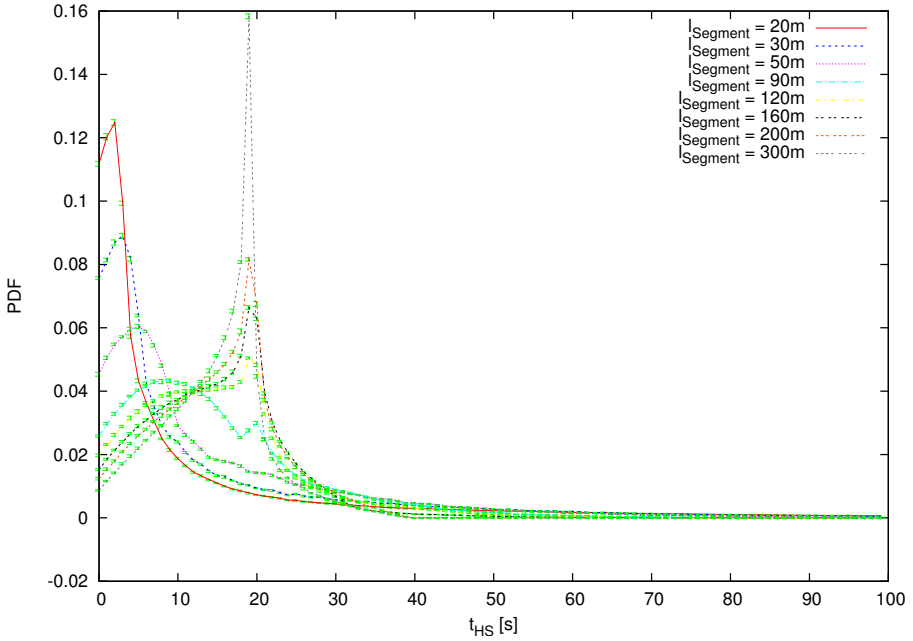

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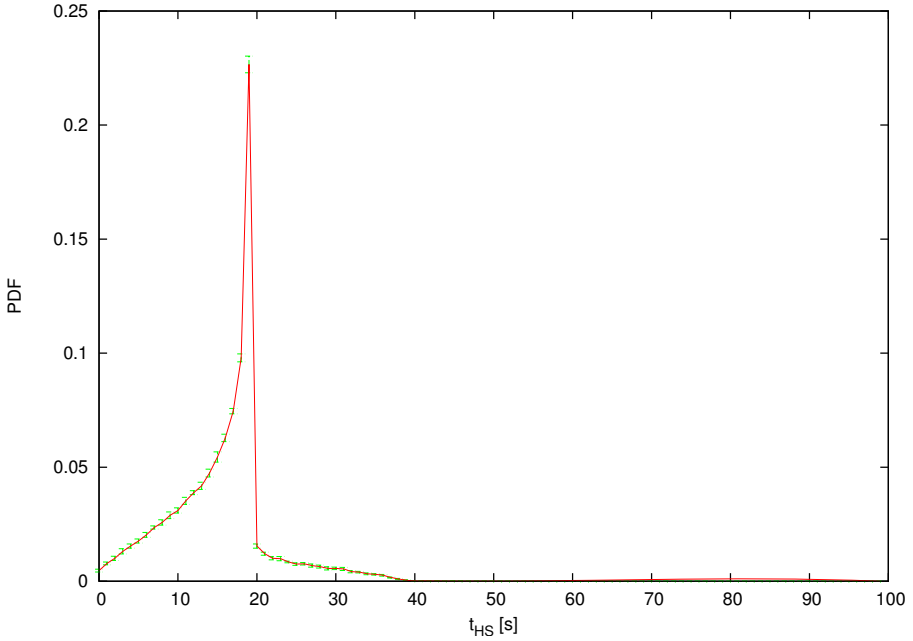
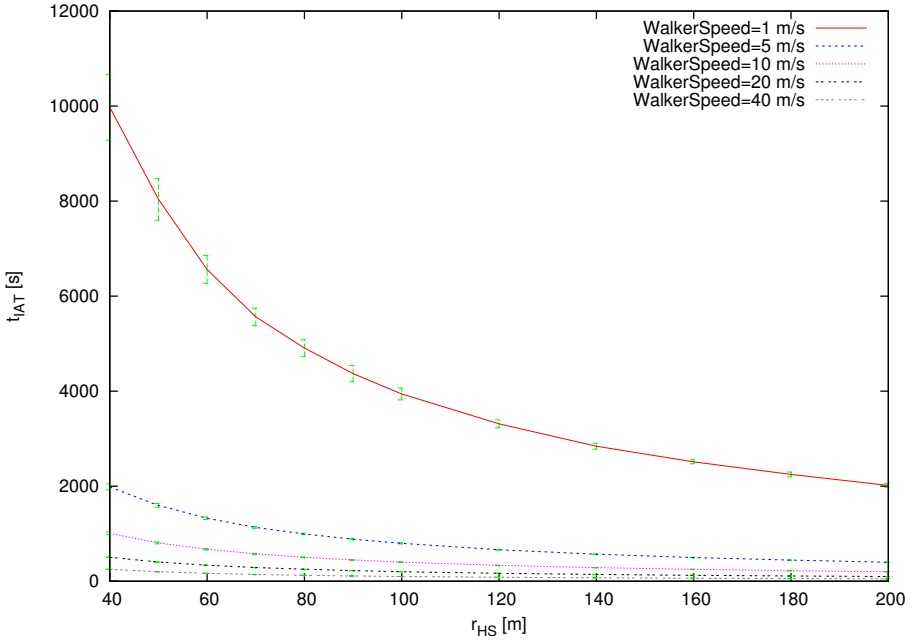


Visit Inter Arrival Time Average vs. Speed

- **Random Direction,** $l_{Segment} = 100m$
  hot-spot: $\vec{p}_{HS} = (250\text{m}, 200\text{m})$



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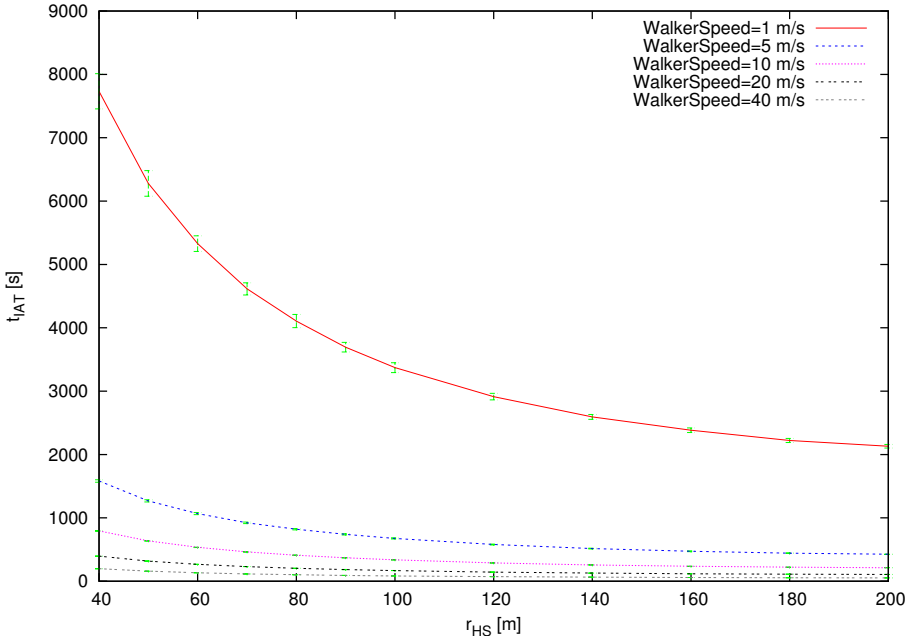

Visit Inter Arrival Time Density vs. Speed

- **Random Direction, Opposite Enter,** $l_{Segment} = 100m$
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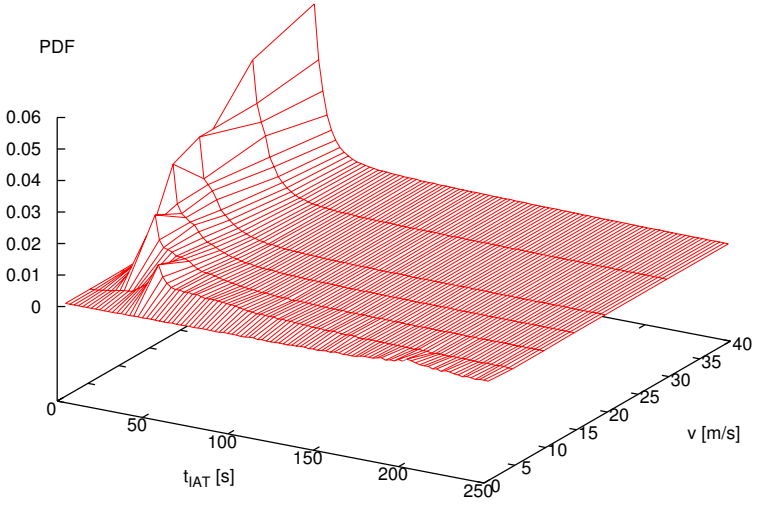
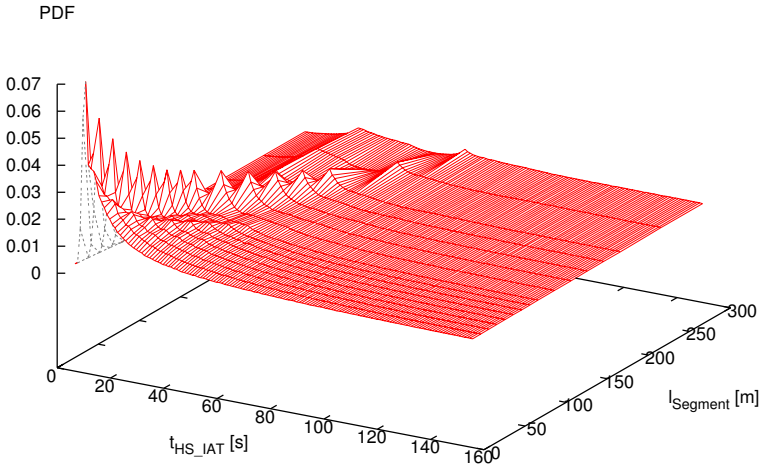


Visit Inter Arrival Time Density vs. Segment Length

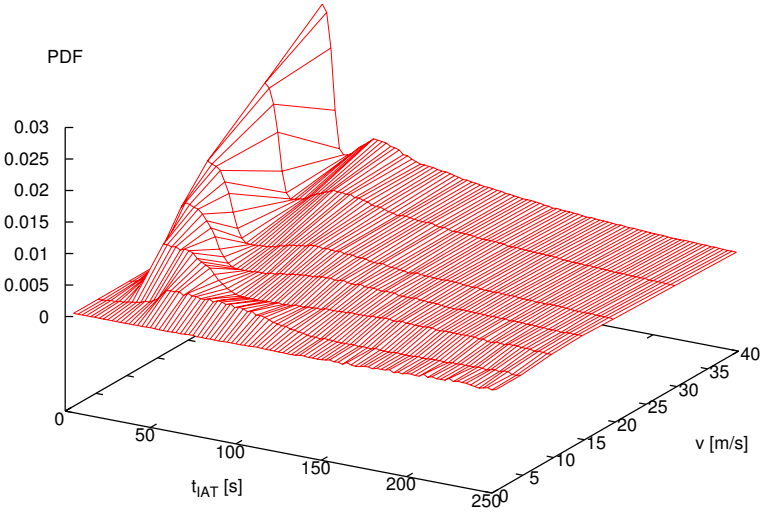
Random Direction, Opposite Enter, $v = 10\frac{m}{s}$

hot-spot: $\vec{p}_{HS} = (250\text{m}, 200\text{m})$**,** $r_{HS} = 100m$

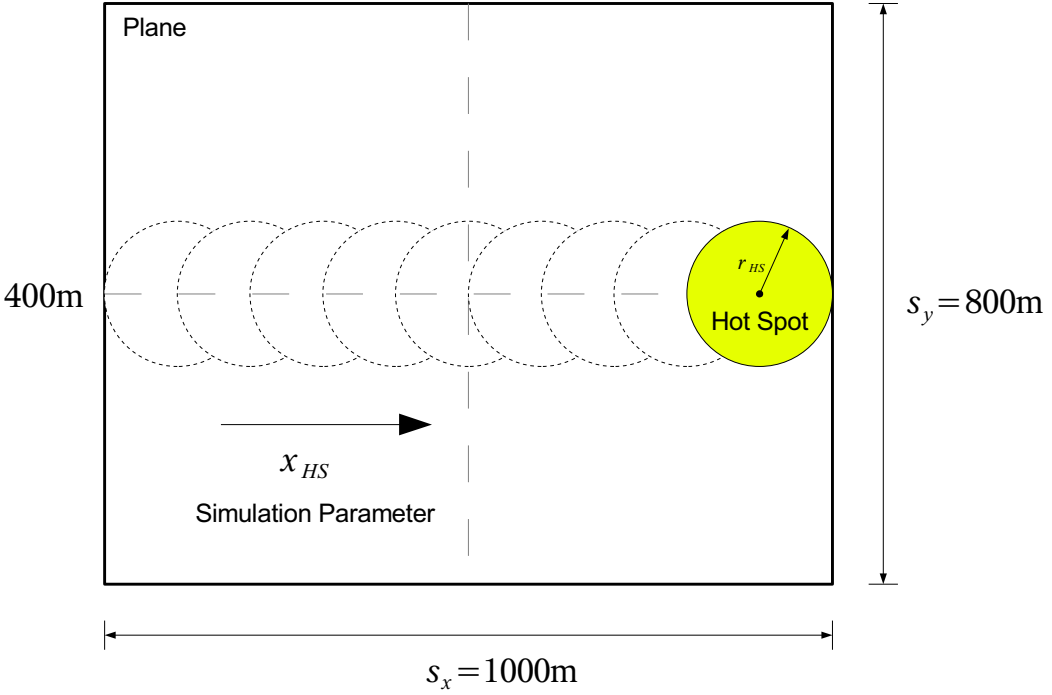


Visit Inter Arrival Time Density vs. Speed

- **Random Waypoint**
  hot-spot: $\vec{p}_{HS} = (250\text{m}, 200\text{m})$, $r_{HS} = 100m$

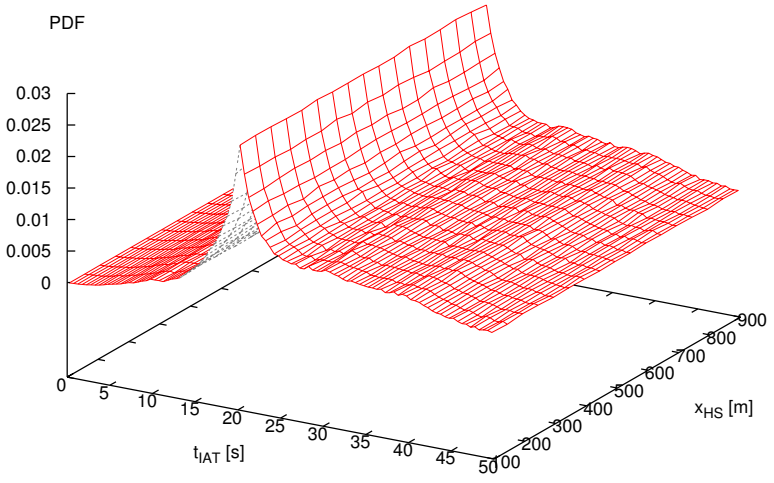


Simulation Scenario "Hot-Spot Position"



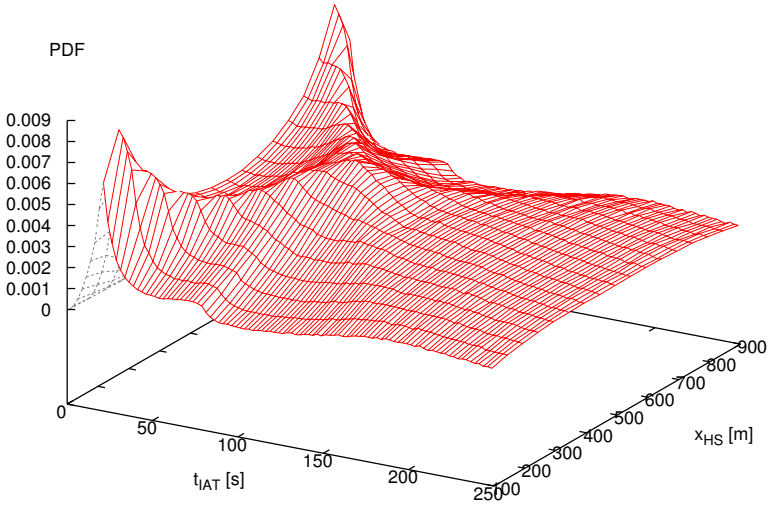
Visit Inter Arrival Time Density

- **Random Direction, Opposite Enter,** $l_{Segment} = 100m$, $v = 10\frac{m}{s}$ **hot-spot:** $\vec{p}_{HS} = (*, 400\text{m})$, $r_{HS} = 100m$



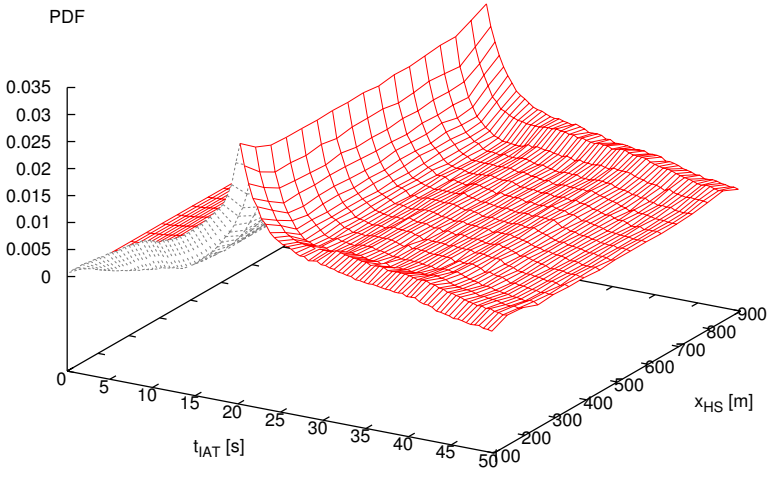
Visit Inter Arrival Time Density

- **Random Waypoint,** $v = 10\frac{m}{s}$
  hot-spot: $\vec{p}_{HS} = (*, 400\text{m})$**,** $r_{HS} = 100m$



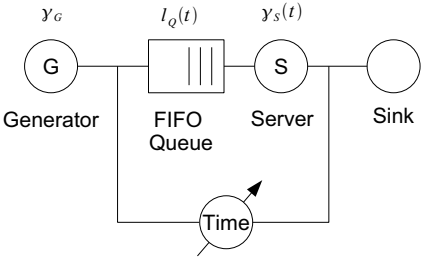
Visit Inter Arrival Time Density

- **Random Direction, Reflect,** $l_{Segment} = 100m$, $v = 10\frac{m}{s}$
  hot-spot: $\vec{p} = (*, 400\text{m})$,$r_{HS} = 100m$



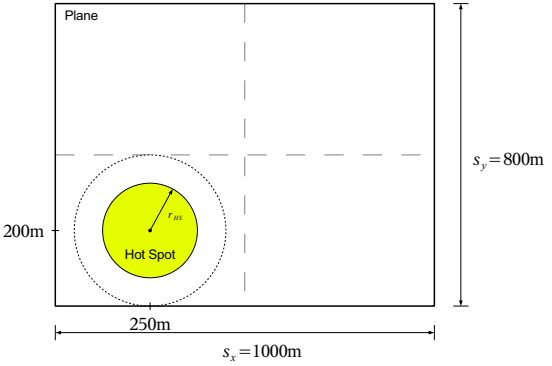
Simple Fluid Flow Model

- **Source / Generator**
  - continuous flow γ_G
  - no packets / frames
- **Queue**
  - unbounded FIFO Queue
- **Server**
  - continuous flow $\gamma_S(t)$
  - $\gamma_S(t) = \gamma_{S,i}$ for $t_i < t < t_{i+1}$
- **Sink**



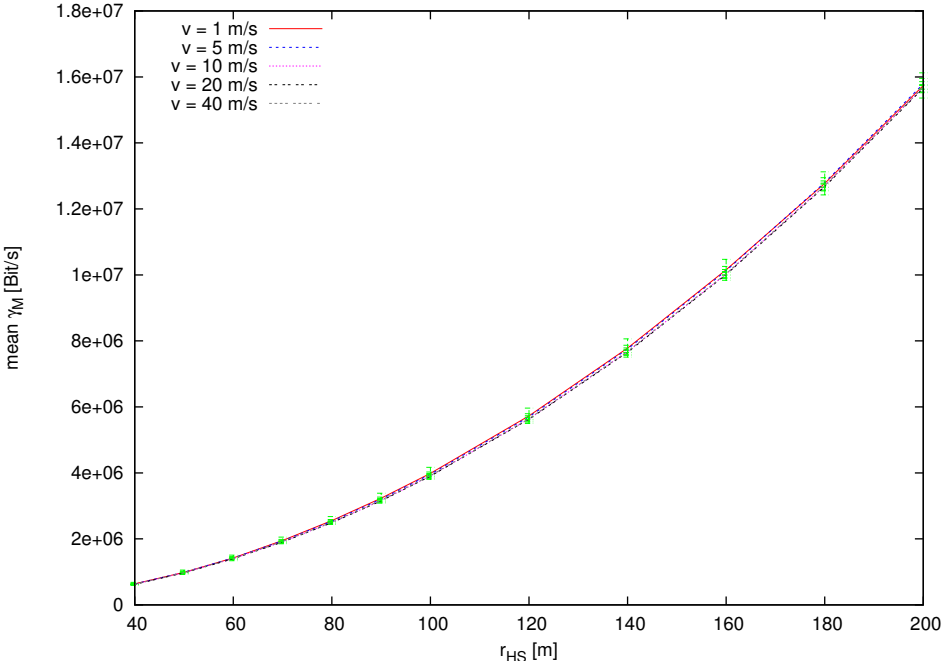
Measures

- **Mean Bitrate** $\bar{r}$
- **Virtual Waiting Time** $\overline{t_W}$



Mean Bandwidth

- **Random Direction, Opposite Enter,** $l_{Segment} = 100m$
  hot-spot: $\vec{p}_{HS} = (250\text{m}, 200\text{m}), r_{HS} = 100m$



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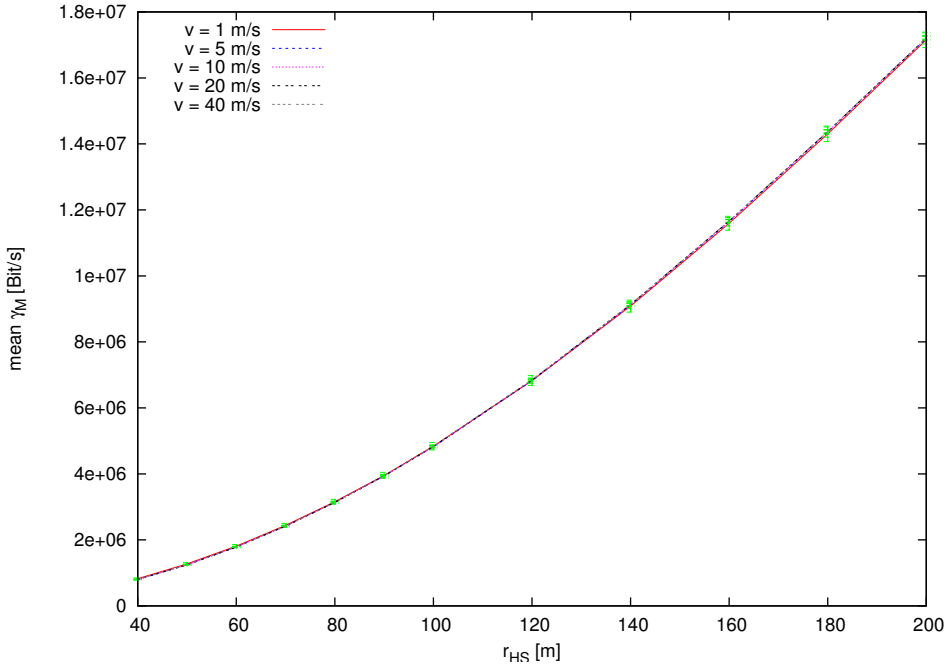
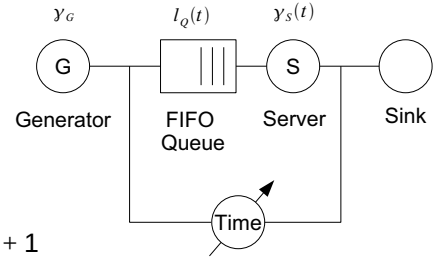
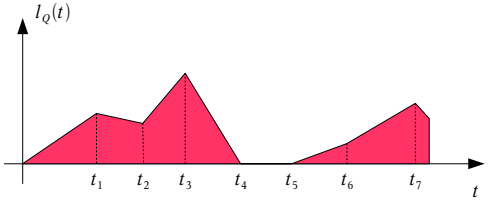


Virtual Waiting Time

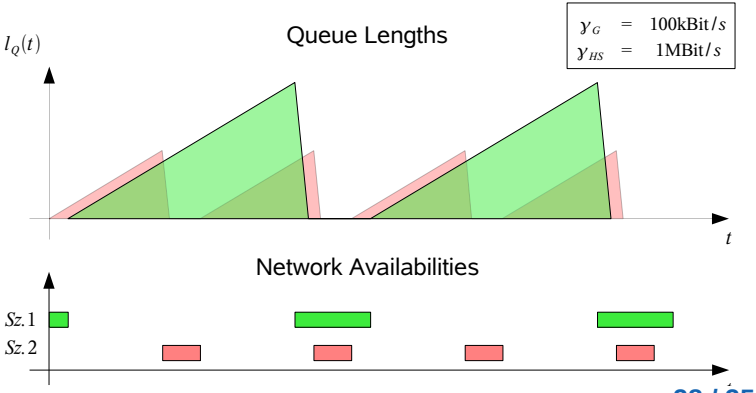
- **Definition**
  - $l_Q(t) = \int_0^t \gamma'_S(t')dt'$
  - $l_Q(t) = l_Q(t_i) + (\gamma_G - \gamma'_{S,i})t \quad t_i \le t \le t_{i+1}$





- $\overline{t_W} = \frac{1}{T}\int_T l_Q(t)dt$

- **Measure for**
  - hot-spot frequency
  - regularity



Queue Length Trace

- **Random Direction,** $l_{Segment} = 100m$**,** $v = 10\frac{m}{s}$
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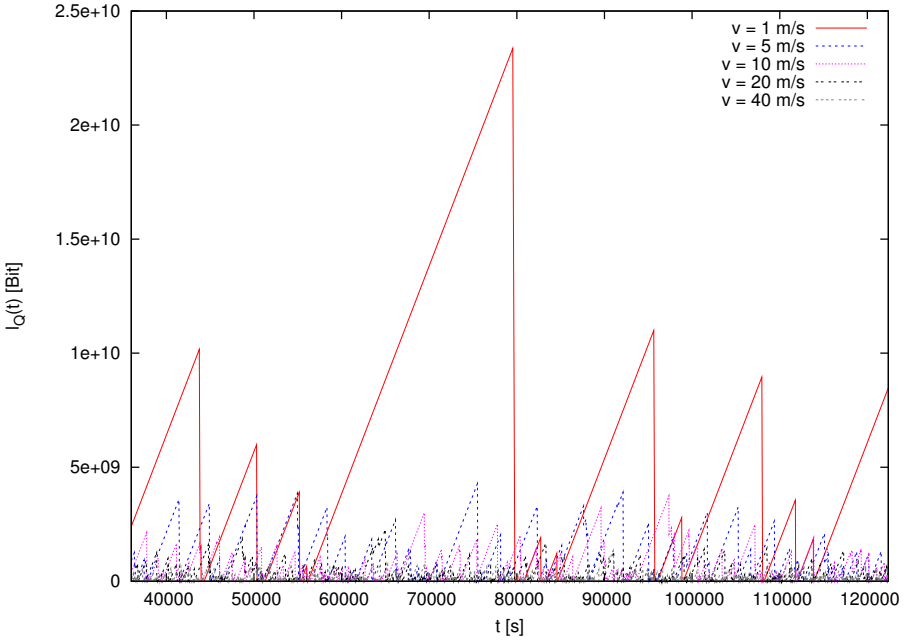

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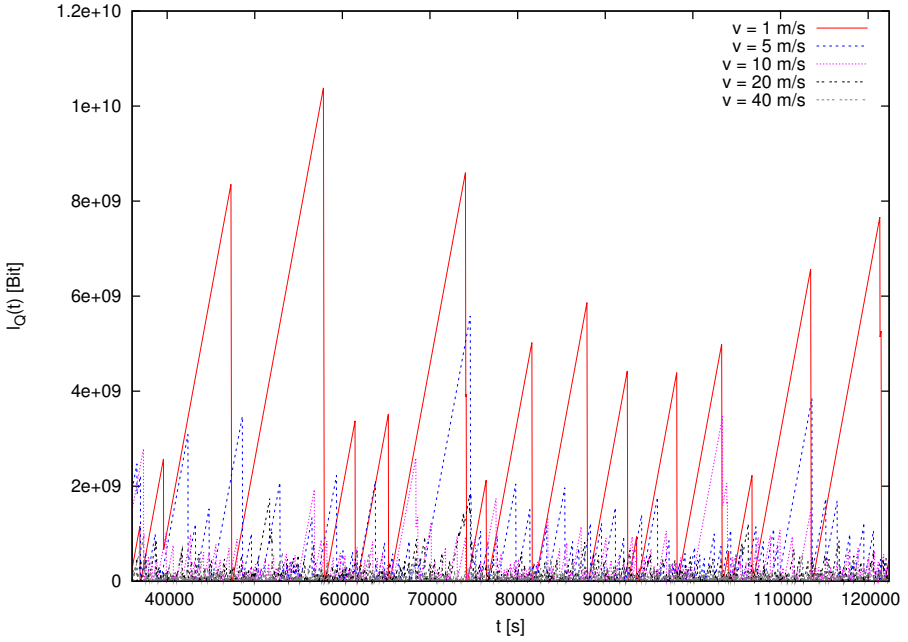

Virtual Waiting Time

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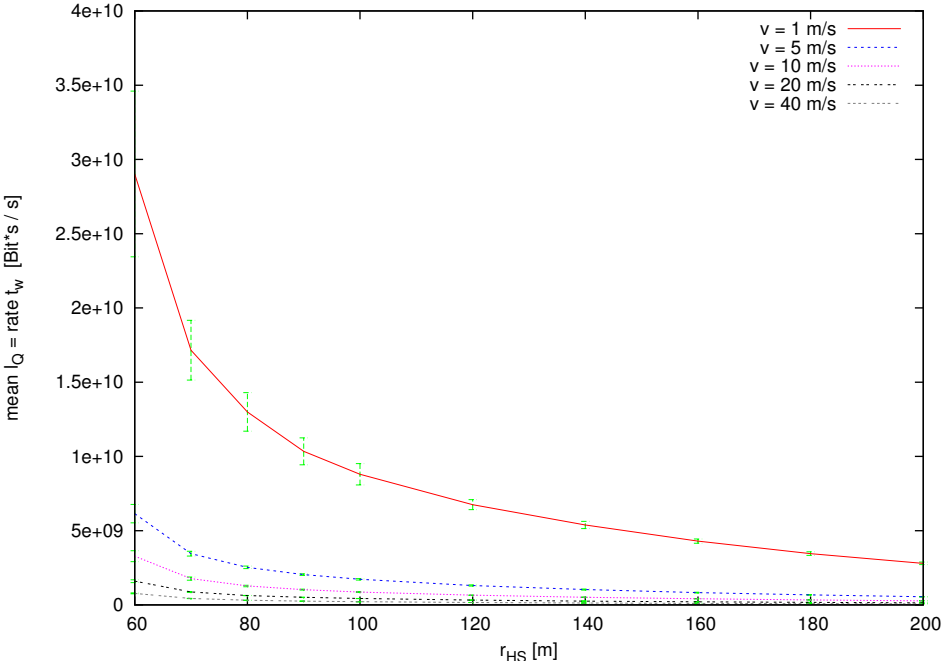

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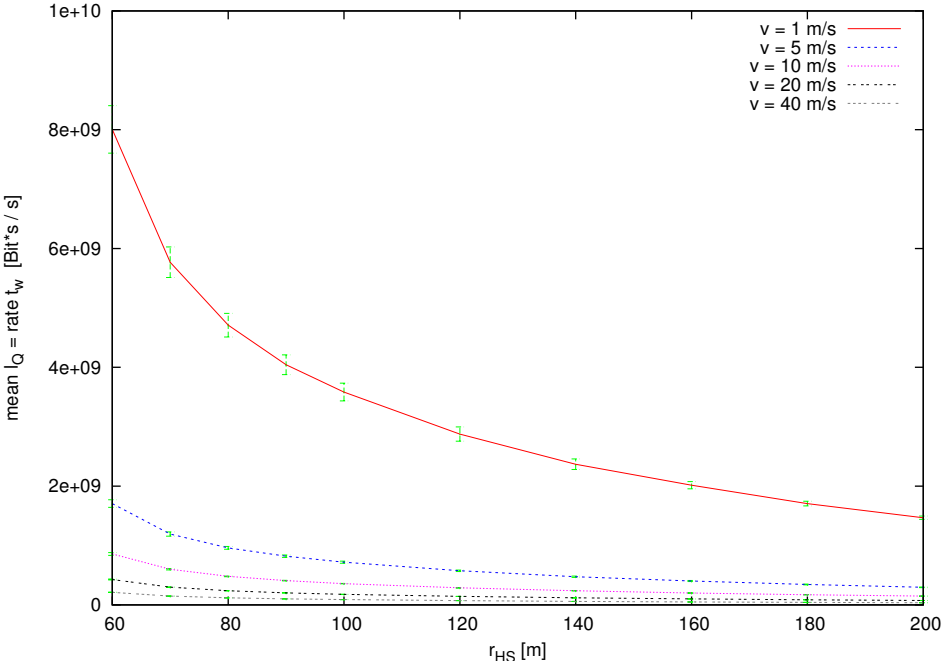

Hot Spot Communications

Next: Evaluation of Communication Mechanisms against these models

- opportunistic scheduling
- adaptive transport

Conclusions

- **Model comparison**

	Random Direction	Random Waypoint
Flexible parameterization	+	-
Low hot-spot location dependency	+/++	-
Good for analytical approaches	- (many case studies)	+

- **Metrics**
  - mobility metrics
  - hot-spot visit metrics
  - communication metrics
- **Mobility model + hot-spot topology -> resource model**

➥Only to look at the mean bandwidth is not enough!

Conclusions and Further Work

Further Work

- **Multi-user scenarios**
- **Multi hot-spot scenarios**
- **Communication issues**