Dependability Evaluation of mobile applications

Connectivity Dynamics in Vehicular Freeway Scenarios

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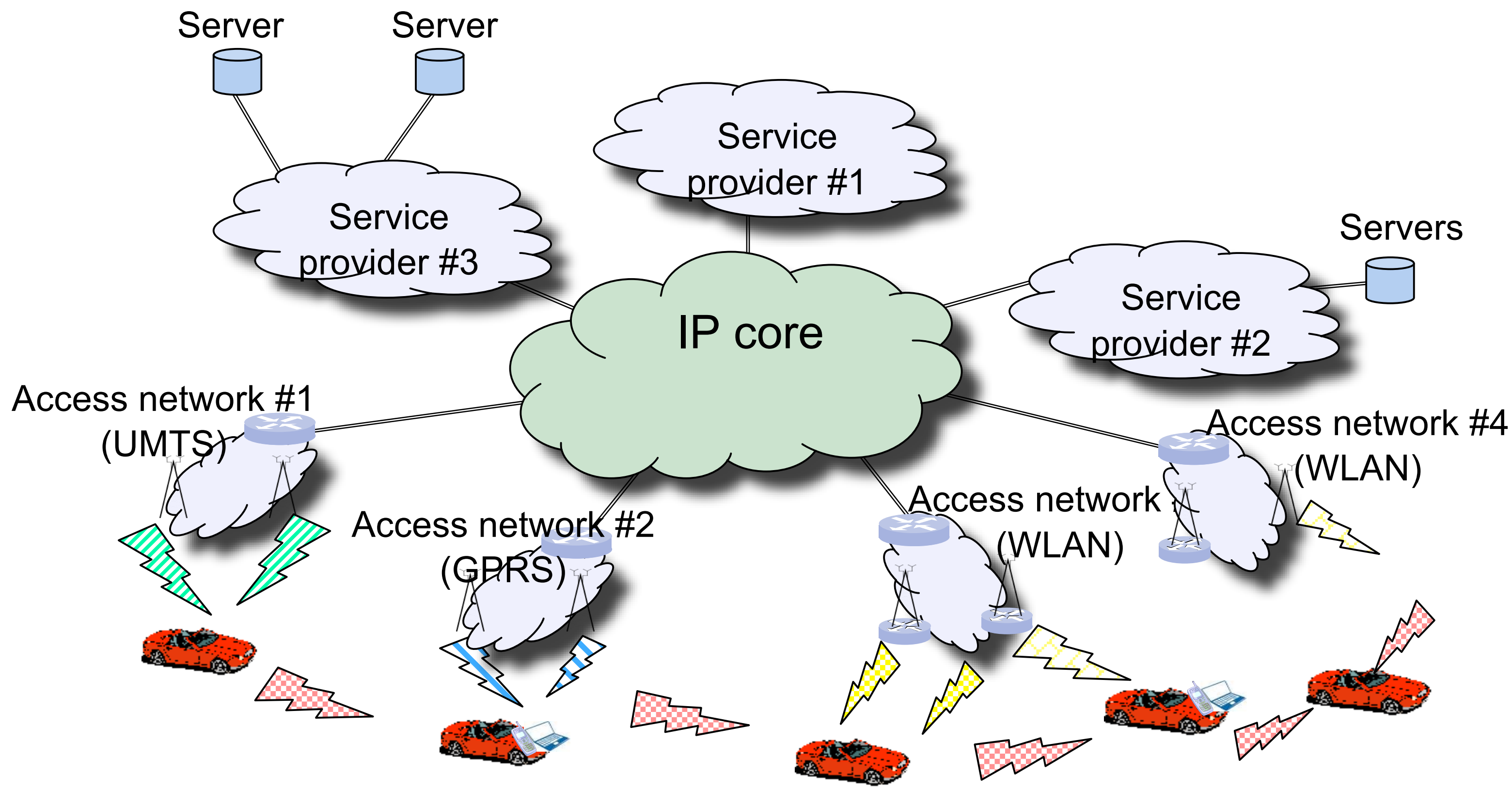
- Highly-Dependable IP-based NETworks and Services
- FP6 Specific Targeted Research Project (STREP)
- Jan. 2006 - March 2009
- 9 parteners - 8 european projects
  - Industry : 4 , Research Labs & Universities : 5
  - Industrial Advisory Board : BMW (G), Nokia (F), Renault, France Telecom, Intects (I), Siemens (G)

HIDENETS: Context and objectives



- Develop and analyze end-to-end system dependable solutions for scalable distributed applications and mobility aware services services
- Automotive Applications
  - Car-to-car communication with server-based infrastructure

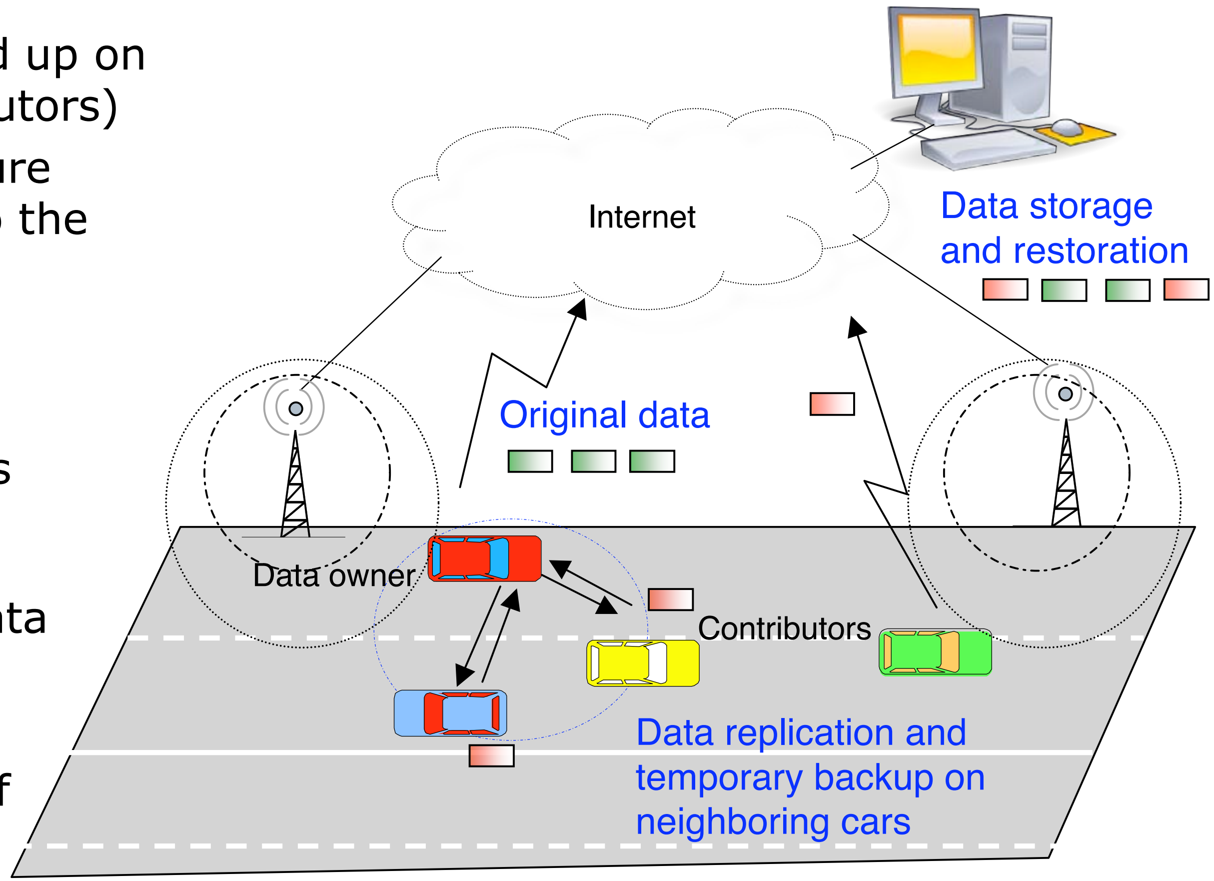
Distributed Black Box Application

Scenario

- Data owner collects data at regular intervals
- Data replicated and backed up on neighbouring cars (contributors)
- Data stored on infrustructure when access is available to the owner or the contributors

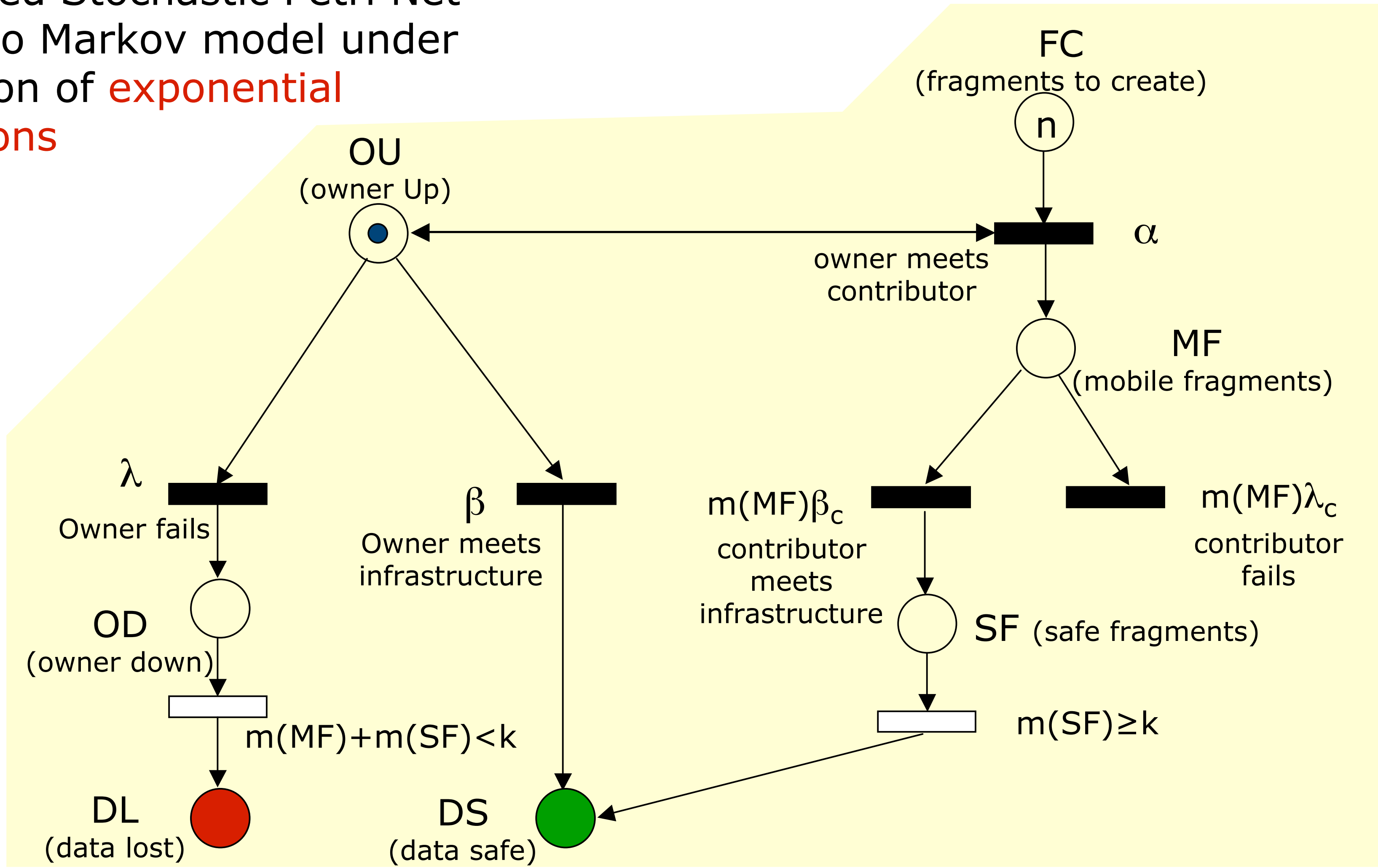
- Data replication based on erasure codes (n,k)
  - n: number of fragments generated
  - k: minimum number of fragments to restore data

- Evaluation
  - Comparative analysis of replication strategies
  - Measure: Probability of data loss



GSPN model for (n,k) erasure codes

Generalized Stochastic Petri Net mapped to Markov model under assumption of exponential distributions

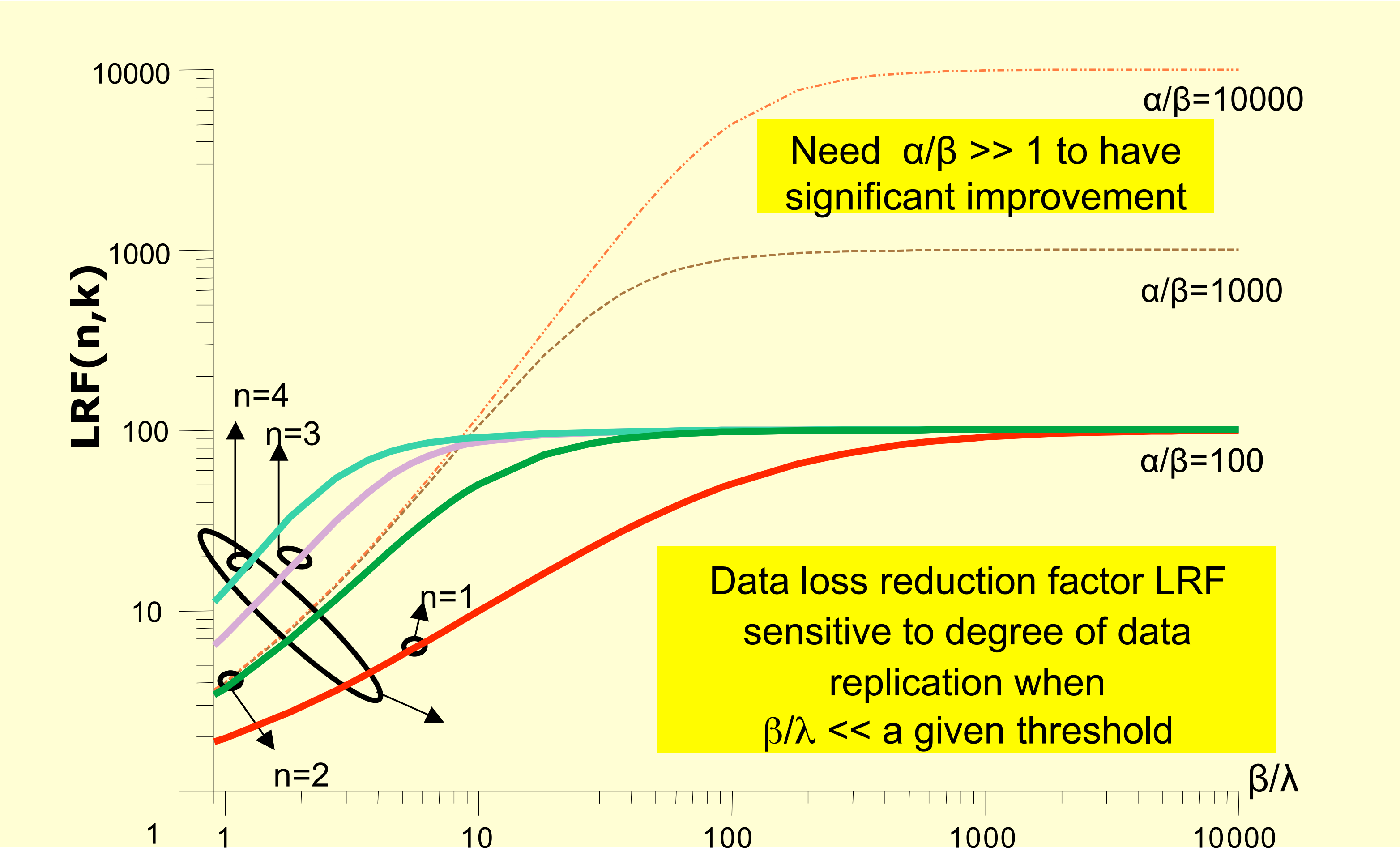


L . Courtes, O. Hamouda, M.Kaâniche, M.O.Killijian, D.Powell, Dependability evaluation of cooperative backup strategies for mobile devices, PRDC 2007, Melbourne (Australia), 17-19 December 2007, pp.139-146

Example results from GSPN model

Comparison: with/without cooperative backup

LRF(n,k) = data loss reduction factor



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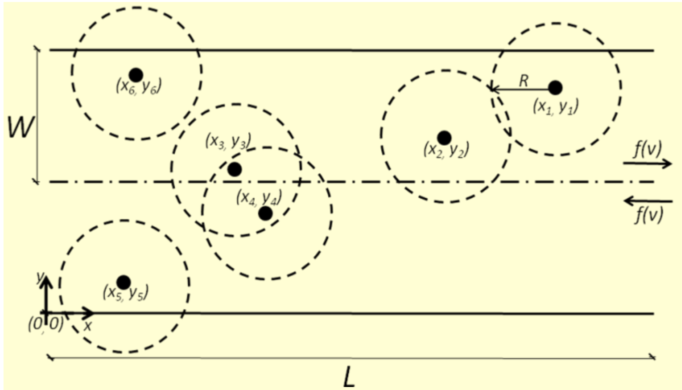
Analysis of node encounters distribution

1. Analytical proof of *Poisson* encounter process
    - Cars move independently according to speed distribution *f(v)*
        - opposite directions on upper and lower half
    - Initial placement of cars according to a spatial *Poisson* process (ρ: car density)
    - Fixed communication radius for the cars: *R*

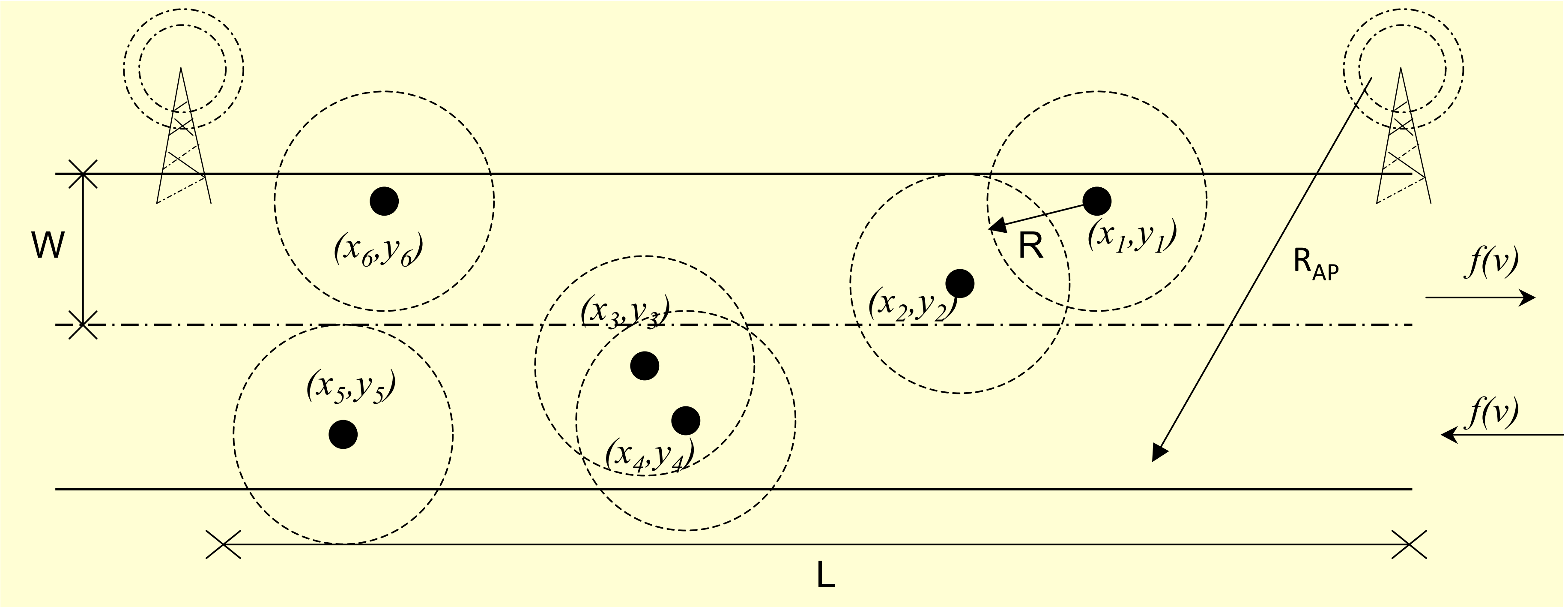
encounter rate $\alpha = \rho * E|V|$

2. *Poisson* distribution confirmed by simulation of more complex scenarios with independent movement of cars
    - single-hop and multi-hops scenarios
    - connectivity duration analysis



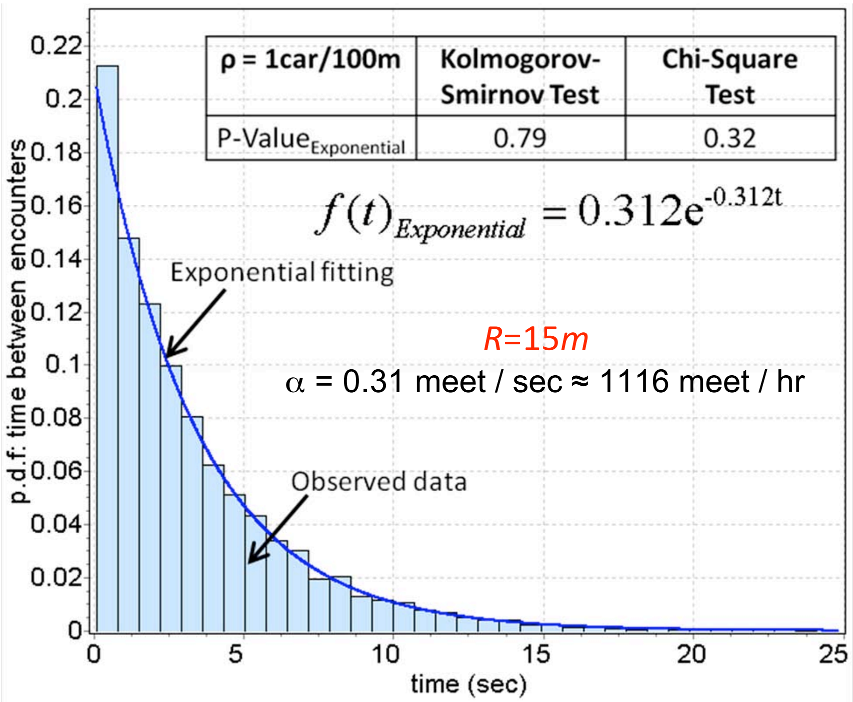
3. Mobility with dependencies between vehicles
    - variable speeds, cars can get slowed down by cars in front of them, cars can change lanes, correlation between cars trajectories
    - encounters described by non-homogeneous *Poisson* process

Simulation of connectivity dynamics

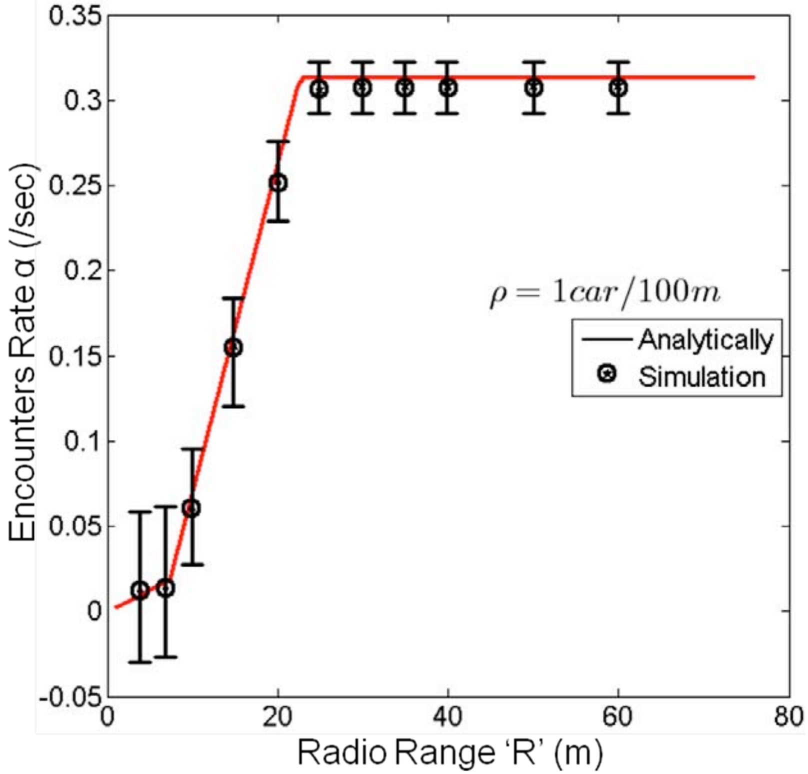


V_{min}=80*km/hr*; V_{max}=130*km/hr*; V_1=108*km/hr*; W=15*m*; x_1=2500*m*; y_1=5*m*;
Δt=0.1*sec*; L=4000*m*; simulation steps=600*300 *times*;

SIMULATION RESULTS: TIME TO ENCOUNTER A NEW NEIGHBOR



Empiric probability density function of the time between single-hop encounters for, car density ρ = 1*car*/100*m*: simulation results and comparison to an exponential distribution



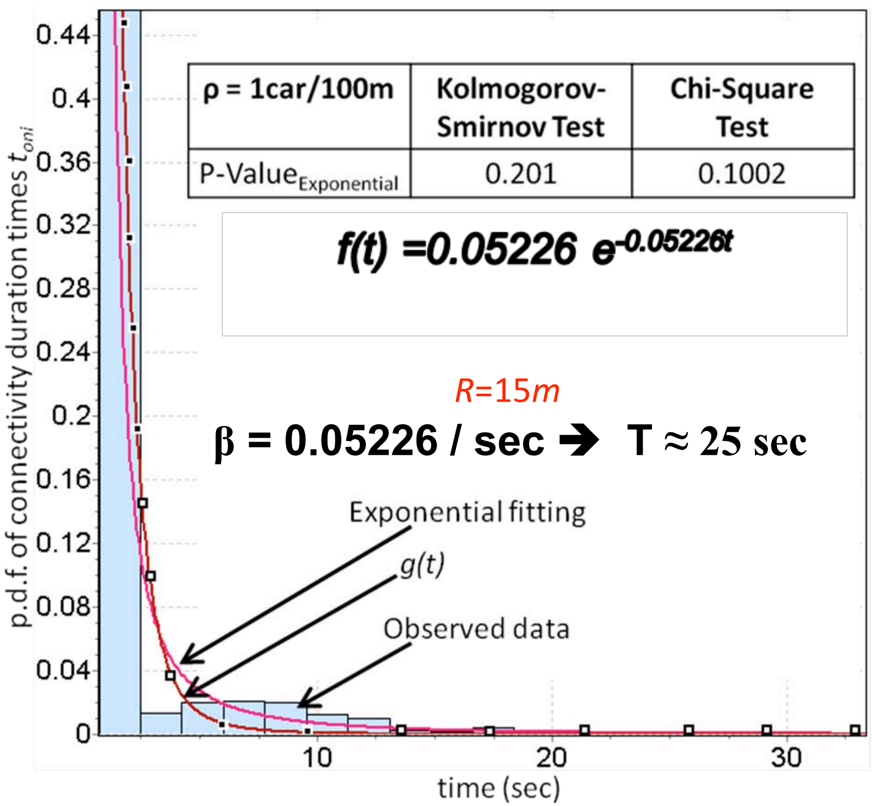
The impact of the Radio Range on the encounter rate α

V_{min}=80*km/hr*; V_{max}=130*km/hr*; V_1=108*km/hr*; W=15*m*; x_1=2500*m*; y_1=5*m*;
Δt=0.1*sec*; L=4000*m*; simulation steps=600*300 *times*;

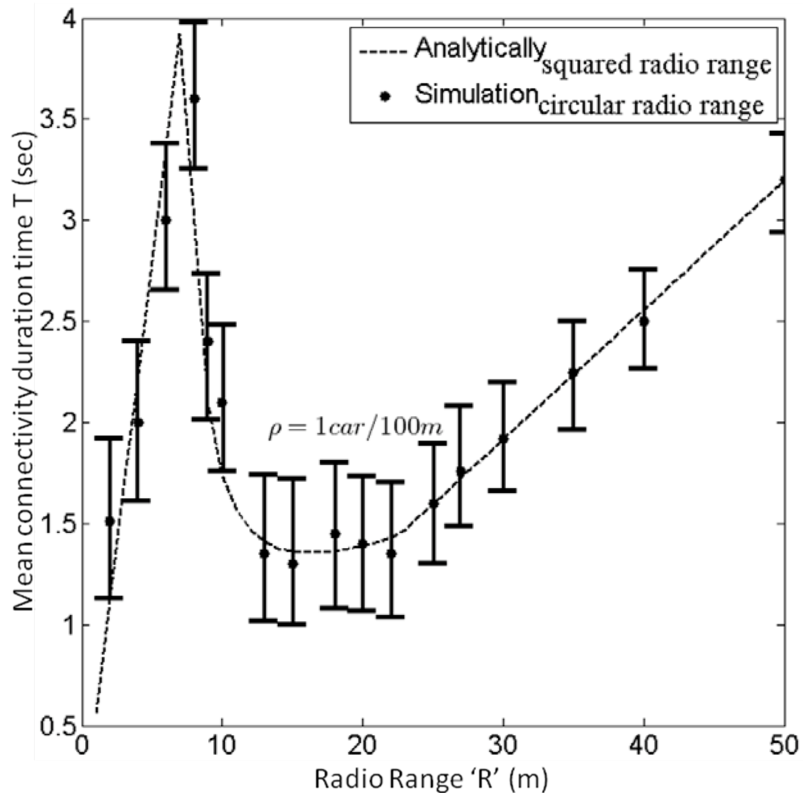
SIMULATION: CONNECTIVITY DURATION

T : connectivity duration random variable with p.d.f *g(t)*
V: relative speed with p.d.f *f(v)*

➔ $$g(t) = f(2R/t)\frac{2R}{t^2}$$



Mean Time To stay connected to neighbor



Future work

- Assess sensitivity of results when the exponential distribution is not acceptable

- Analyse connectivity parameters distribution in other traffic scenarios (simulation, real traces)

- More general assumptions
  - Trust and cooperation wrt participating nodes
    - Selfish nodes, Remuneration/Penalties
  - Other dissemination strategies
    - more than one fragment per node, flooding,
  - Take into account Data freshness in data restoration strategies