

## *On Natural Mobility Models*

Vincent Borrel, Marcelo Dias De Amorim,  
Serge Fdida

LIP6/CNRS  
Université Pierre et Marie Curie  
Paris, France



## Autonomic Communications means mobility

- Autonomic networks adapt to situation changes
- Radio networks depend on users' trajectories and relative positions
- Different mobility representations
  - Mobility traces
  - Mobility models } complimentary

## Contribution

- A new mobility model based on observed features of sociology and natural graphs
- Fine-grained collective mobility using individual decisions
- Behavioural approach to mobility models
  - Expresses the causes
  - Richer features

## Different mobility models

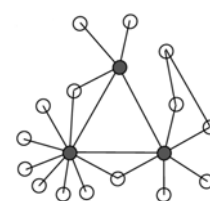
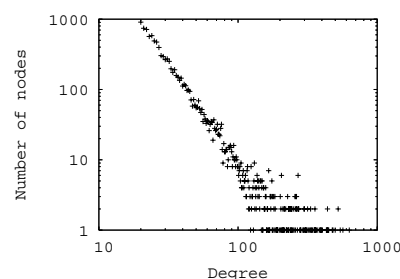
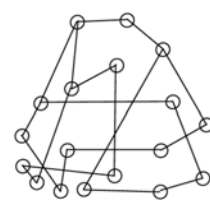
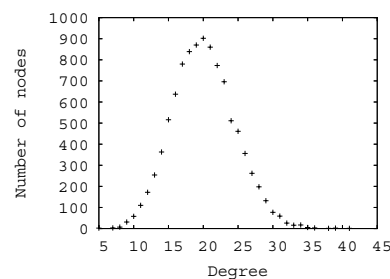
- Individual mobility
  - Random Walk, Random Waypoint, Random Direction
  - Gauss-Markov, Boundless area
  - City section, Vehicular
- Group mobility
  - Reference Point, Nomadic, Column, Pursue
  - Exponential Correlated
  - **Problem : group rigidity**
    - Group and Swarm, Social Graph-based

## Natural Networks

- Observation domains
  - Biology, Sociology, Economics
  - Computer Networks, Engineering
- Characteristics
  - Scale-Free
  - High Clustering
  - Low Diameter
- Very different from Random Graphs

## Scale-Free characteristic

- Random networks (standard model)
  - Each possible link exists with a probability  $p$
  - Exponential degree distribution
- Scale-free Networks
  - Power-law degree distribution:  $p(k) \sim k^{-\lambda}$
  - Few wealthy, many poor
  - Often indicates hierarchical organization



## Scale-free graph construction using preferential attachment

- Albert-Barabasi model
  - Growth
  - Preferential attachment

$$\Pi(k_i) = \frac{k_i}{\sum_j k_j}$$

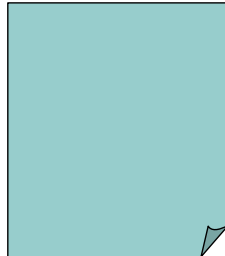
## The PRAGMA model

- Two populations: *Individuals & Attractors*
- Poisson inter-arrivals, random lifetimes
- Individuals: choice-displacement-stay cycles
- Choice: preferential attachment on attractor popularity, weighted by distance

$$\mathcal{A}_{(z_i, a_l)} = \frac{\left(1 + \sum_{z_j \in \mathbf{Z}, z_j \neq z_i} B(z_j, a_l)\right)}{\sqrt{(X_{a_l} - X_{z_i})^2 + (Y_{a_l} - Y_{z_i})^2}}$$

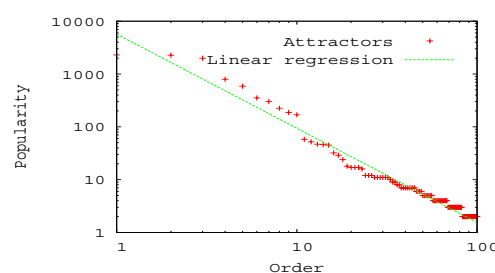
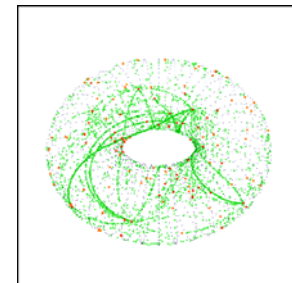
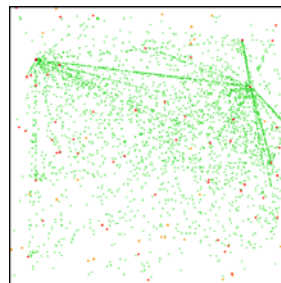
- Environment : bounded or boundless

## The simulator in action



## Results

- Scale-free attractor popularity distribution (Bounded and Boundless)
- Predominant paths appear
- Collective behaviours (but individual decisions)
- New class of mobility model: gathering mobility



## Conclusion

- Realistic mobility model based on observed sociological findings and real-life graphs
- Scale-free features
  - comforted by recent observations (chaintreau et al, 2005)
- Collective behaviours emerge from individual decisions
- Models mobility at its roots: behaviours

## Further developments

- Generalize scale-free over distance for more dimensions
  - Associate euclidian distance to cost functions expressed on several dimensions
- Characterize group join/split
- Unify behavioural mobility and stochastic mobility

## References

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