



HAL
open science

Studying information dissemination in a d2d network using Call details records

Rachit Agarwal, Vincent Gauthier, Monique Becker, Thouraya
Toukabrigunes, Hossam Afifi

► **To cite this version:**

Rachit Agarwal, Vincent Gauthier, Monique Becker, Thouraya Toukabrigunes, Hossam Afifi. Studying information dissemination in a d2d network using Call details records. Digital Symposium: Grande échelle & Complexité, Institut Mines-Télécom, Mar 2014, Paris, France. 10.6084/m9.figshare.69817 . hal-01302824

HAL Id: hal-01302824

<https://inria.hal.science/hal-01302824>

Submitted on 15 Apr 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

LABS



AUTHORS

Rachit Agarwal
(rach.agarwal@gmail.com)

Vincent Gauthier
(vincent.gauthier@telecom-sudparis.eu)

Monique Becker
(monique.becker@telecom-sudparis.eu)

Thouraya Toukabrigunes
(thouraya.toukabrigunes@orange.com)

Hossam Afifi
(hossam.afifi@telecom-sudparis.eu)

PARTNER



ABSTRACT

In a network of devices in close proximity such as Device to Device (D2D) communication, we study the dissemination of public safety information at country scale level. In order to provide a realistic model for the information dissemination, we extract spatial distribution of the population of Ivory Coast from census data and determine migration pattern from the call detail records obtained during the Data for Development (D4D) challenge [1]. We latter apply epidemic model towards the information dissemination process. We then propose enhancements to the dissemination model by adding latent states and beamforming to the epidemic model. In this paper, we study the transient states towards the evolution of the population having the information for different cases. Through the results we show that enhancements in the dissemination process can be achieved in large and realistic scenarios.

CONTEXT: DISSEMINATION OF EMERGENCY INFORMATION IN METAPOPOPULATION AND DYNAMIC NETWORK USING EPIDEMIC MODEL.

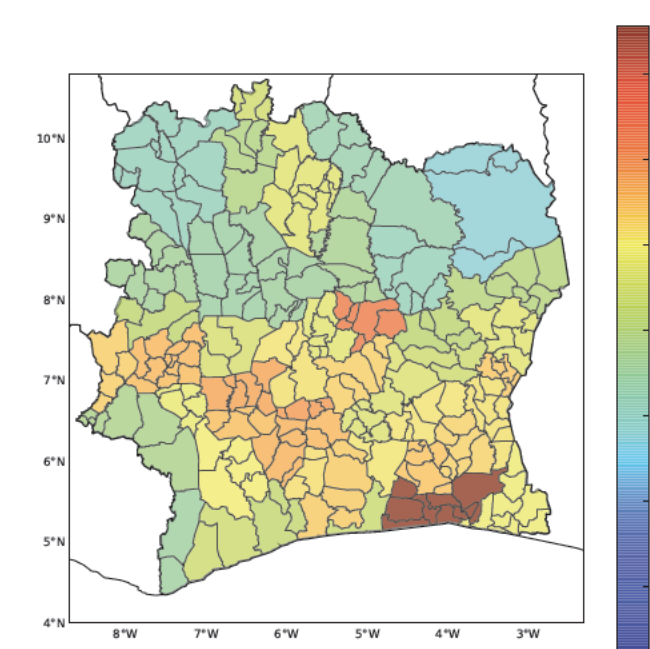
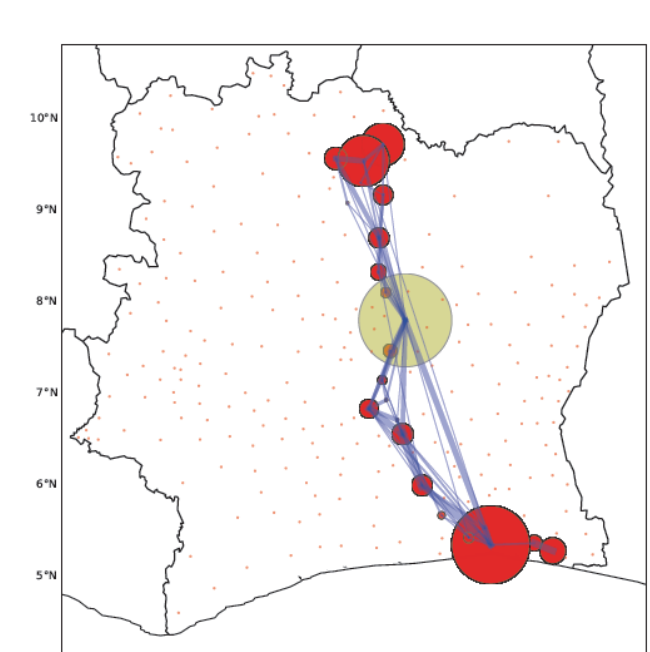
DATA ANALYSIS

- Extract User's movement at the country level from Call Details Records provided by Orange [1].
- Generate transition probability matrix (ν) from all movement patterns.
- Determine population density from Census data.

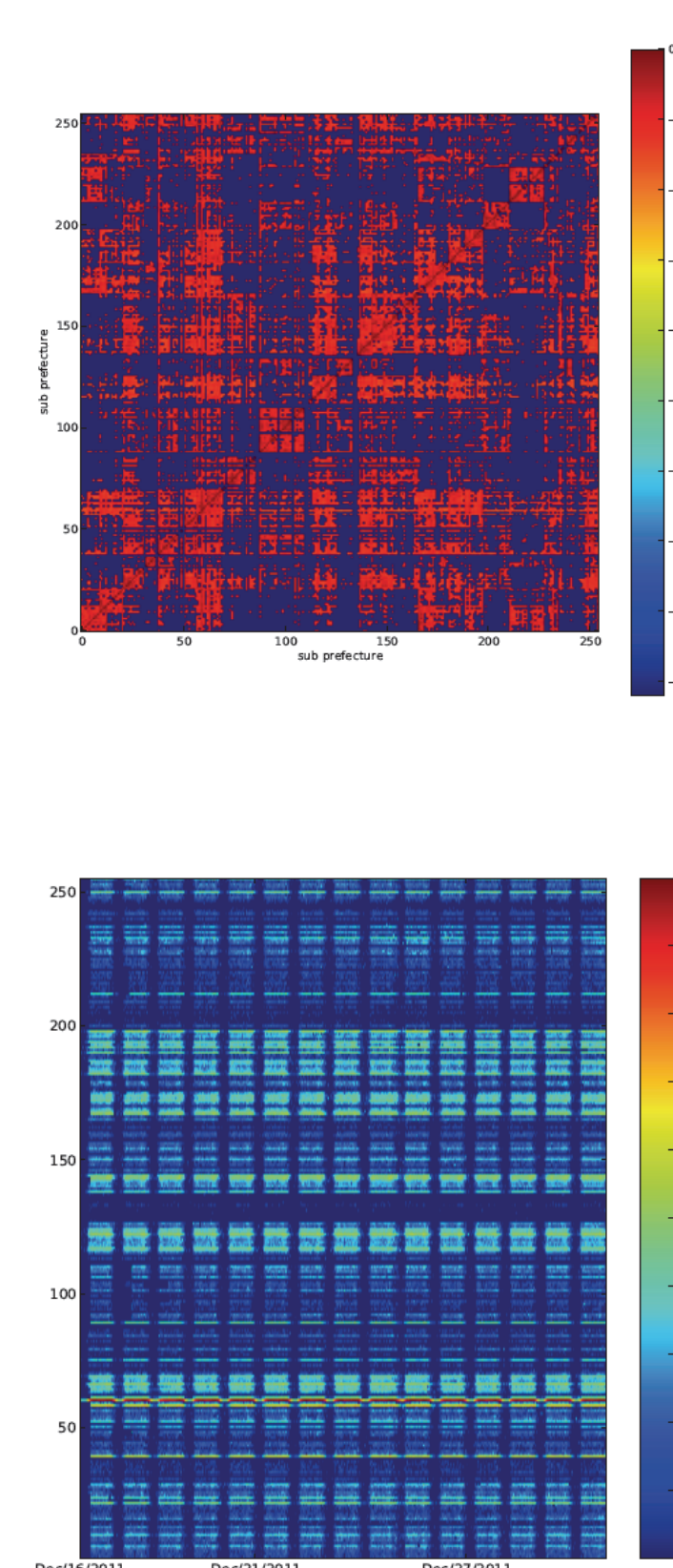
MODEL

- Split the country into metapopulation [2,6] (subprefecture).
- Generate mobility between each meatpopulation base on our analysis of the CDR dataset of Orange.
- Add latent states to the initial SIR model in order to modelize a variable density of user in each metapopulation.
- Generate the epidemic process in order to simulate the spreading of information across the country.

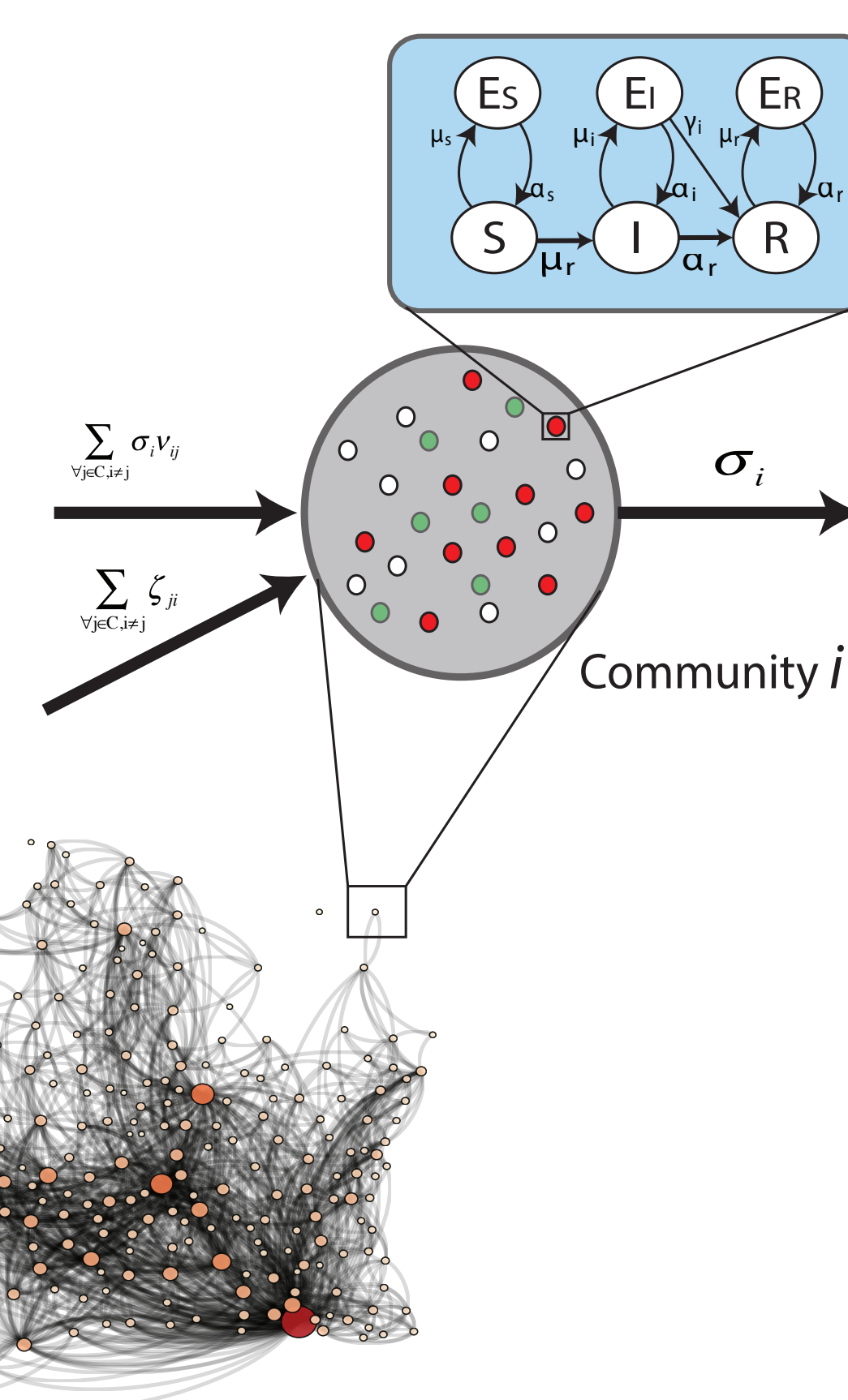
RAW DATA



ANALYSIS



DIFFUSIONS MODEL (BASE ON SIR SPREADING PROCESS)

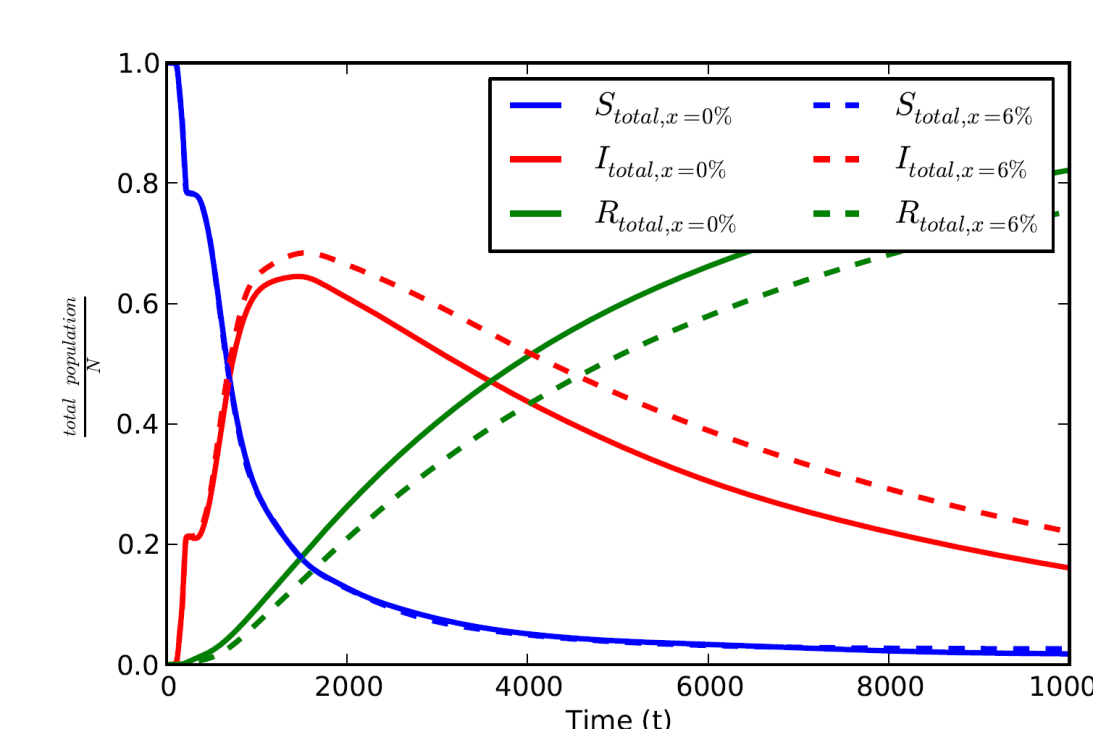
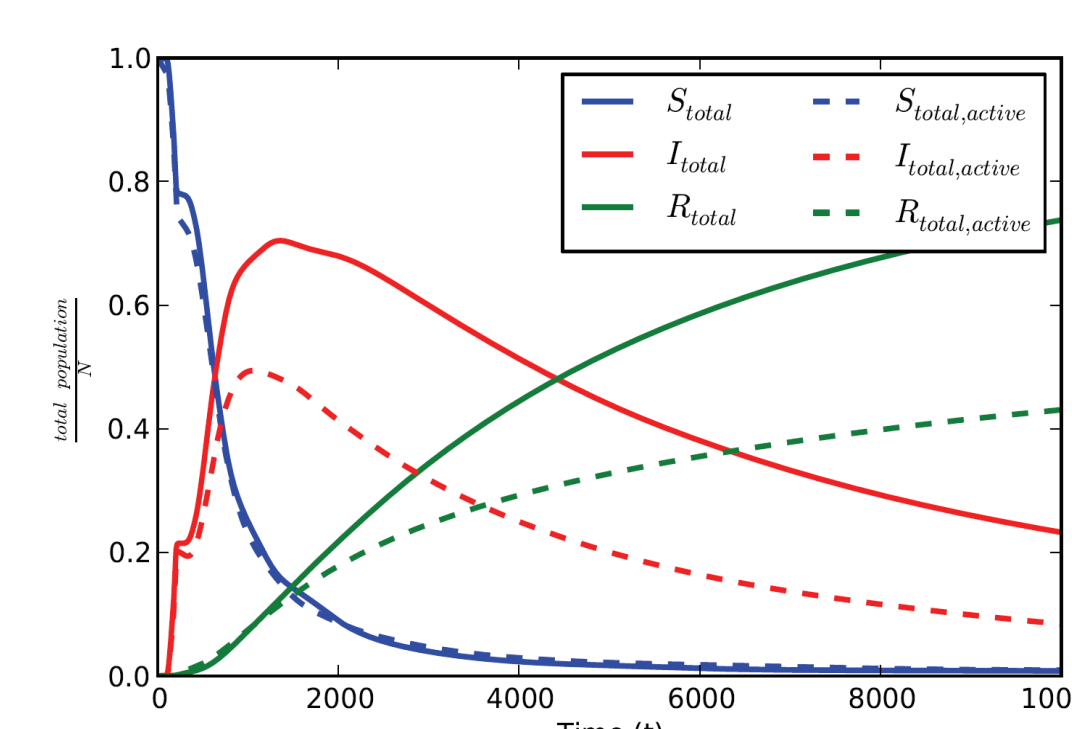


RESULTS

- Variable people density affects the information spreading in mobile environment.
- Information spreading through local interaction could lead diffusion at country scale in a timely maner (Cf. Video [3]).
- We solve numerically a large system of differential equations to compute the spatio-temporal evolution of the diffusion.
- We validate the result by simulations using the Gillespie algorithm (Tau-Leap).

CONCLUSION

We first display as supplementary material a movie [3] that shows the diffusion process in Ivory Coast. We can see that the diffusion that initially takes place in the East side of the country, is spreading quickly into the major cities of Ivory Coast through: Abidjan (the economic capital), Bouak (the second largest city), Youkouso, (Political Capital) Soudre. Later on, the information is spreading more slowly into less populated areas, mostly from Est to West. The West side of the country is well know to be mostly an agricultural region (Cocoa, coffee, rice). We can also notice that the diffusion of the information takes a very long time to spread over the northern part of the country. As Suggested by [4] whom have been working on the same datasets, the fact that the northern part of the country is less diffusive might be the consequence of socio-economic disparity in place inside the country. Highlighting on the fact that this part of the country is still relatively "disconnected from the main economic and political center of Côte d'Ivoire".



REFERENCES

- [1] V. BLONDEL, M. ESCH, C. CHAN, F. CLEROT, P. DEVILLE, E. HUENS, F. MORLOT, Z. SMOREDA, AND C. ZIEMICKI, Data for Development: The D4D Challenge on Mobile Phone Data, <http://arxiv.org/pdf/1210.0137v1.pdf>, 2012.
- [2] D. WATTS, R. MUHAMAD, D. MEDINA, AND P. DODDS, "Multiscale, Resurgent Epidemics in a Hierarchical Metapopulation Model," Proceedings of the National Academy of Sciences of the United States of America, vol. 102, pp. 11157-11162, August 2005.
- [3] R. AGARWAL, V. GAUTHIER, AND M. BECKER, Diffusion process using mobility data available for D4D challenge, <http://dx.doi.org/10.6084/m9.figshare.69817>, 2013.
- [4] C. ANDRIS, L. BETTENCOURT, Development, Information and Social Connectivity in Côte d'Ivoire, *Netmob*, 2013.
- [5] R. AGARWAL, A. BANERJEE, V. GAUTHIER, M. BECKER, C. K. YEO, AND B. S. LEE, Achieving Small-World Properties using Bio-Inspired Techniques in Wireless Networks, *The Computer Journal*, vol. 55, pp. 909-931, March 2012.
- [6] V. COLIZZA AND A. VESPIGNANI, Epidemic modeling in metapopulation systems with heterogeneous coupling pattern: theory and simulations, *Journal of theoretical biology*, vol. 251, no. 3, pp. 450-467, 2008.

