LINC

Learning about Interacting Networks in Climate

Marie Curie Initial Training Networks (ITN)

FP7- PEOPLE - 2011- ITN

Grant Agreement No. 289447

WorkPackage WP2: *Interacting Networks*

Deliverable D2.3

Report on the parameters and classifications that characterize interacting networks

Dong Zhou, Bar Ilan University

Release date: August 2013

Status: Public

EXECUTIVE SUMMARY

The main objective addressed by the current report is to provide analytical machinery for understanding interacting networks. The cascade of failures in the problem at hand is dominated by 5 parameters. Knowledge of these parameters is the most complete description of interacting networks. Interacting networks are broadly classified to subcritical and supercritical cases. The dynamics is categorized into 3 distinguished stages: a) quick exponential collapse towards a plateau level. b) stagnation inside the plateau. c) total exponential collapse. The subcritical case exhibits only stages a & b, while the supercritical case exhibits the 3 stages.

We regard this analysis to be a critical step towards understanding climate in a framework of interacting networks. This result impacts only WP2 in a direct way. To bridge between these theoretical results and possible climate scenarios we wish to further extend our analysis to include not only percolation theory of interacting networks, but also synchronization theory, as well as including the case of links that exhibit different time scales. Such an extension is expected to be applicable in all WPs, due to the fact that it is closer to the actual procedure of constructing climate networks (see WP1 in **Error! Reference source not found.**).

Deliverable Identification Sheet

Grant Agreement No.	**PITN-GA-2011-289447**
Acronym	**LINC**
Full title	**Learning about Interacting Networks in Climate**
Project URL	http://climatelinc.eu/
EU Project Officer	Lucia PACILLO

Deliverable	**D2.3 Report on the parameters and classifications that characterize interacting networks**
Work package	**WP2 Interacting Networks**

Date of delivery	**Contractual**	M 15	**Actual**	01-08-2013
Status	version. 1.00		final ☑ draft ☐	
Nature	Prototype ☐ Report ☑ Dissemination ☐			
Dissemination Level	Public ☑ Consortium ☐			

Authors (Partner)	Dong Zhou (BIU)			
Responsible Author	Dong Zhou		**Email**	zhoudongbnu@gmail.com
	Partner	BIU	**Phone**	<optional>

Abstract (for dissemination)	The main objective addressed by the report is the analytical machinery for understanding interacting networks. The cascade of failures in the problem at hand is dominated by 5 parameters. Knowledge of these parameters is the most complete description of interacting networks. Interacting networks are broadly classified to subcritical and supercritical cases.
Keywords	<key word 1><key word 2>…

Version Log			
Issue Date	**Rev No.**	**Author**	**Change(s)**
01-08-2013	001	Dong Zhou	First and final draft

TABLE OF CONTENTS

1 INTRODUCTION

In a system of interdependent networks, an initial failure of nodes invokes a cascade of iterative failures that may lead to a total collapse of the whole system in a form of a first order transition. The system collapses in 3 main stages: a quick exponential collapse towards a plateau level. b. stagnation inside the plateau. c. total exponential collapse.

2 MAIN RESULTS

The parameters which quantify the cascading process, according to our findings are :

1. The fraction of initial failed nodes in the original (i.e. fully functional) network: p
2. The number of cascade iterations: τ
3. Fluctuations in the number of cascade iterations: std(τ)
4. The system size (number of nodes): N
5. The standard deviation of the giant component during the plateau stage: std(ψ)

These parameters obey general scaling laws, the derivation and Monte Carlo simulations of which, are summarized in a new paper, available on the arxiv : Zhou, Dong, et al. "On the Dynamics of Cascading Failures in Interdependent Networks." arXiv preprint arXiv:1211.2330 .

These laws are as follows:

$$\tau \sim N^{1/3} \cdot f\left[(p_c - p) \cdot N^{1/\alpha}\right],$$

$$std(\tau) \sim N^{1/3} \cdot g\left[(p_c - p) \cdot N^{1/\alpha}\right]$$

where g and f are scaling functions with a cross over.

3 SUMMARY

To summarize, we have developed a general theory which predicts all possible dynamics, and the fluctuations between different realizations of systems with similar dynamics, of interacting networks under percolation.

4 REFERENCES

[1] Dong Zhou, Amir Bashan, Yehiel Berezin, Reuven Cohen, Shlomo Havlin, *On the Dynamics of Cascading Failures in Interdependent Networks* . arXiv:1211.2330 (http://arxiv.org/abs/1211.2330).