Cybersecurity, Modern Mathematics and Statistics

Jacek Brodzki, Joerg Fliege, Ian Leary and Robin Mitra
Mathematics
University of Southampton

New methods for security challenges
The complexity of modern computer networks, communications systems, power grids and the ubiquity of large data sets requires new mathematical and statistical methods that allow efficient real-time analysis of accuracy that matches the requirements.

Among the main problems studied at Southampton are:
• Understanding complex and dynamic systems
• Blackouts in communication networks and power grids
• Geometry and Topology of Large Data Sets
• Modern Cryptography and code breaking
• Identity disclosure in partially synthetic data

This work brings together
Pure and Applied Mathematics
Statistics
Operational Research

Recent developments in mathematics have blurred the boundaries between disciplines and led to new approaches to challenging practical problems. Large data sets and complex systems are natural areas of applications.

Analysis of Online Social Networks
• The OR group is a partner in ROBUST EU FP7 project: https://www.robust-project.eu/ €11m funding for 11 partners, among them IBM, SAP, etc.
• Role Analysis in online networks (fraudsters, scammers, experts, users, new users, etc.)
• Forecasting of network roles & network structure
• Forecast changes of network content & sentiments
• Structural Analysis of underlying network graphs (spectral analysis, fast matrix exponentials, etc.)
• Agent based simulation of online networks
• Further work for Home Office UK (Central Intelligence Hub): analysis of crime networks

Distributed computing and optimisation
• Joint optimisation of network performance whilst keeping sensitive information local
• Joint work with Alcatel-Lucent, Bell Labs, & Qualcomm

Scale dependent analysis of networks
Analysis of modern communication, transmission and energy networks requires tools from geometry and topology to study integrity, stability, and security and to enable network operators to predict and deal with a variety of threats.

Structure of complex interacting systems
Interacting systems are at the centre of many problems within cybersecurity. A main challenge here is to develop a flexible and realistic set of tools to analyse complex interacting networks.

Preventing blackouts
Large scale catastrophic events in power grids and communication networks cause massive disruption and great economic loss. Such events can result from malfunction or malicious action.

Modern spectral geometry provides tools for protecting networks by identifying and isolating the problem area while enabling the rest of the network to function normally.

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