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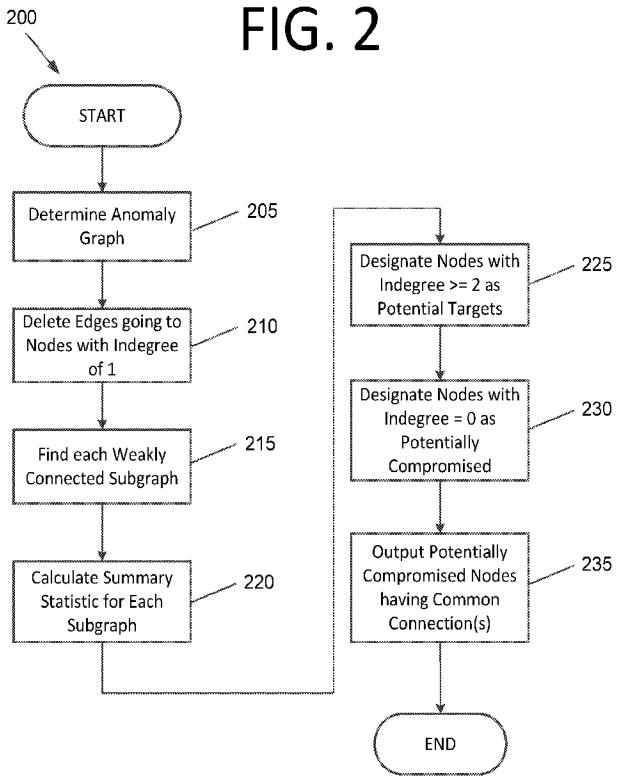
[Continued on next page]

(54) Title: ANOMALY DETECTION TO IDENTIFY COORDINATED GROUP ATTACKS IN COMPUTER NETWORKS

FIG. 2



(57) Abstract: Systems, apparatuses, methods, and computer programs for detecting anomalies to identify coordinated group attacks on computer networks are provided. An anomaly graph of a network including nodes, edges, and an indegree of the nodes in the anomaly graph may be determined. Nodes with an indegree of at least two may be designated as potential targets. Nodes with no incoming connections may be designated as potentially compromised nodes. The designated potentially compromised nodes may be outputted as potentially associated with a coordinated attack on the network when the potentially compromised nodes connect to one or more of the same potential target nodes.

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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USPC - 726/23
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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USPC - 726/23

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USPC - 709/224, 714/26, 714/37, 714/38.14, 714/39, 714/47.1, 714/E11.029, 726/25 (See keywords below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Thomsoninnovation.com; Patbase; Google Scholar; Google Patents; Google.com; Freepatentsonline; ProQuest Dialog
Search Terms: Network, graph, tree, map, node, vertex, edge, link, connection, path, indegree, in-degree, incoming, inbound, ingoing, anomalous, malicious, intrusion, hack, attack, suspicious, behavior, trend, pattern, monitor, zero, no,

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2007/0209074 A1 (COFFMAN), 06 September 2007 (06.09.2007), entire document, especially Abstract; para [0042], [0050]-[0051], [0065]-[0068], [0071], [0091], [0166]	8 ---- 10
X --- Y	US 2005/0044406 A1 (Stute), 24 February 2005 (24.02.2005), entire document, especially Abstract, para [0014]-[0015], [0073]-[0074], [0121]	8 ---- 10
X --- Y	US 2007/0226796 A1 (Gilbert et al.), 27 September 2007 (27.09.2007), entire document, especially Abstract, para [0038], [0048], [0050], [0080], [0137]	8 ---- 10
Y	Neil. "Scan Statistics for the Online Discovery of Locally Anomalous Subgraphs." In: Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy , The University of New Mexico, May, 2011 [retrieved on 28 October 2013 (28.10.2013)] Retrieved from the Internet <URL: http://repository.unm.edu/handle/1928/13885 >, entire document, especially Abstract; Figure 7.5; pages 2-3, 61	10
A	US 2011/0231937 A1 (LIPPMANN et al.), 22 September 2011 (22.09.2011), entire document, especially Abstract, para [0021]-[0023], [0027]-[0028]	1-20
A	US 2010/0192226 A1 (Noel et al.), 29 July 2010 (29.07.2010), entire document, especially Abstract, para [0046], [0057]-[0062]	1-20

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"A" document defining the general state of the art which is not considered to be of particular relevance
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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Akoglu et al. "Anomaly Detection in Large Graphs." In: CMU-CS-09-173 Technical Report, School of Computer Science Carnegie Mellon University, Pittsburgh, November, 2009 [retrieved on 28 October 2013 (28.10.2013)] Retrieved from the Internet <URL: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.188.2619 >, entire document, especially Abstract	1-20
A	Djidjev et al. "Graph Based Statistical Analysis of Network Traffic." In: Proceedings of the Ninth Workshop on Mining and Learning with Graphs. August 2011 [retrieved on 28 October 2013 (28.10.2013)] Retrieved from the Internet <URL: http://csr.lanl.gov/detection/>, entire document, especially Abstract	1-20
A	US 2011/0154119 A1 (WANG et al.), 23 June 2011 (23.06.2011), entire document	1-20
A	US 2004/0133672 A1 (BHATTACHARYA et al.), 08 July 2004 (08.07.2004), entire document	1-20