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Based on the Part of Routing Information Congestion Modeling Research with the Large-Scale Network

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Abstract

Based on communication network as the background, this paper established a model to capture the cascading failures. The relationship between the local routing congestion information mean dynamics. In this model, according to new congestion function defined by each node (dynamic weight) is put forward based on the local congestion information, routing policy with adjustable parameters. On the BA scale-free network and ER random discusses caused by deliberate attacks on the network of cascading failure behavior. Through numerical simulation main findings, based on the new measure network robustness index (namely, critical production rate, there is a free flow to the phase change of the cascade configuration), the optimal value of existing routing parameters to achieve most robust network and the optimal value related to the network topology.

Keywords: *routing, large-scale network, Congestion function, route discovery, Cascading failure*

1. Introduction

Based on this model also puts forward some protection strategies, these strategies are usually considered from three aspects [1]. A modified network topology [2-4]; The second is to optimize the design of the network capacity [5]; Three is to design a better routing policy [6-8], such as weighted shortest path routing strategy, the weighting scheme on the basis of the static network topology information (*e.g.*, degree and betweenness, *etc*.). Consider the first two aspects of cost and implementation difficulty, design a better routing strategies to effectively utilize the structure and capacity of the network itself will is to improve the actual network robustness against cascading failures are relatively good method. The above is idealized assumptions in the model. In the real system, the traffic is often produced by per unit time is not sure; Also are not necessarily invalid overload node. In addition, more importantly, ignored the many real network system on this model, such as traffic network and communication network in intelligent individuals can according to the environment of intelligent judgment or decision of the important behavior. When intelligent individual existence, if a node transmission efficiency is low, the flow stream can avoid this path and choose higher transmission efficiency path route by, do not have to wait until the node real "closed" and unable to work, that fails will change the path, which is the so-called congestion effects. Has the effect of congestion on the network, therefore, completely different from the traditional network flow distribution mechanism, traditional node on the network load definition method cannot reflect the effect of the nodes on the network congestion by real bearing capacity. Recently there are [9-12] based on the global routing congestion information, puts forward the global congestion effect of cascading

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failure model, to explore the effect of network structure on congestion propagation. In the reality of the large-scale network system, the global congestion information acquisition is extremely difficult, because each individual's information collection, storage and processing power is often limited. From the perspective of the congestion effect of the above two kinds of extreme situations, the congestion effect between a class and its global congestion effects model more practical cascading failure model of its local congestion effects [13-16]. In view of this, based on the communication network as the background, such a model is established to capture the cascading failures. The relationship between the local routing congestion information mean dynamics of in this model, the new congestion function for each node defined (dynamic weight) is put forward based on the local congestion information, routing policy with adjustable parameters. On this basis, the introduction of package containing "jump model, define the node load in more realistic way. In addition, consider a simple and practical overload node failure mechanism. According to the new measurement network robustness against cascading failures, network based on two typical models, and studies the routing parameters, the packet generation rate, congestion information time delay, network topology for congestion (cascading failure) transmission.

2. Related Works

Flow is free on the Internet, congestion rely on many network system in modern society, such as communication network, power grids and transportation network run efficiently and normal function, so the flow mechanics characteristics on the network get the wide attention from many researchers in the field of. Research on this question to the purpose is to control and avoid network congestion, improve the transmission efficiency of the network. Therefore, efficient routing policy on complex network research has always been the hot spot of the enduring topic [17, 18]. Dynamics on the network process relies on the underlying topology structure, thus, revealing the influence of the network topological structure of convection dynamics has become the core issues. Researchers mainly choose in some typical topology based on the study of dynamic behavior and the characteristic of flow on the network, in particular, a large number of real networks were found with scale-free properties, a large part of the work focused on the scale-free network. Here pay attention to the flow of the mechanical characteristics mainly from free flow state to congestion state phase transformation, and through the phase change of network capacity (or network throughput), and the network throughput can measure the transmission efficiency of the network. As a result, to avoid congestion, improve the transmission efficiency of the network usually means to maximize the network throughput, which is highly efficient routing policy design goal. Will just at the beginning of some of the current routing strategy is divided into two broad categories: based on the global static information routing policy and routing strategy based on local static information. Among them, the global static information refers to the entire network topology information, the local static information refers to a range of neighbor nodes topology information down to the two broad categories.

2.1. The Routing Strategy based on Global Static Information

Reality and flow on the network system (hereafter called package), generally is the fastest transport as the goal, therefore the current some real system routing strategy is adopted by the shortest path routing, *i.e.*, according to the node to source node and the node j to destination node packets along it's after the number of nodes (or edge) minimum path transmission. This routing is a typical routing based on global static information, is the foundation and the frame of reference in the study of routing policy. Though shortest path routing strategy can make the transfer faster, but easy to lead to M congestion in the network, especially in scale-free networks, because a few widely degrees of nodes (these degrees generally is between big node) is a lot of shortest path mix, if too many packages to choose node to pass these degrees, easily lead to congestion of the node first, through these nodes will take a longer waiting time. At this point, the shortest path routing policy will not be able to make the package reaches the destination node with the quickest speed, the transmission efficiency of network thus reduced. Consider magnanimous node is the bottleneck of packet transmission, which is a kind of improved shortest path routing, in particular, will any a transmission path between i and j are represented as $P(i \to j) = i \equiv x_0, x_1, \cdots, x_n \equiv j$, Remember that the length of the path is:

$$L(P(i \to j) : \beta) = \sum_{i=0}^{n-1} k(x_i)^{\beta} \qquad (1)$$

Effective path routing has the advantage that when the number of packages on the network is bigger, because the package to avoid magnanimous nodes, can improve the network throughput, alleviate the network congestion, thus improve the transfer efficiency of the network. But when the package quantity is small, package still can avoid not busy magnanimous node, thus longer transmission distance, make the transmission speed is reduced, and the transmission speed is another important measure of network transmission efficiency index. The root causes of this result is that this routing policy only using the static network topology information, it can't reflect the dynamic change of the network. The strategy definition, in many of the paths between source and destination nodes, package node of minimizing the sum of the queue length of path is chosen as the transmission path.

Global dynamic routing is not only consider the global static times, also considered the global dynamic total letter, namely network all nodes of queue length and the history of the queue length of nodes directly reflects the trend of the node congestion. For the use of the global congestion information, scale-free networks under which the strategy, when the package quantity is bigger, also can undoubtedly bypass those with congestion trend of magnanimous nodes, which makes the network throughput greatly more than many, including effective path routing, the throughput under the routing policy. Not only that, while the number of package is small, magnanimous nodes can also be used fully, will not reduce transmission speed. As a result, the transmission efficiency of scale-free networks can get a more comprehensive improvement. However, enterprise bureau of dynamic routing to real-time collection, storage, and update all the queue length of nodes in the network information, in the actual may be difficult to use. Actual should be more than the global dynamic routing local dynamic road mountain, because it only take advantage of local dynamic information.

2.2. The Routing Strategy based on Local Static Information

In the literature [19], Wang Wenxu and others on the scale-free network is put forward based on the local routing strategy of static information. For each node, if the packet's destination node is its neighbor nodes, then the directly to the destination. Then package tend to choose a small degree of nodes, each node in the network on the average number of package. It is precisely because the average effect, making the networkeach node is not easy, first of all, congestion occurs, so as to make the network throughput maximize.

3. System Model Description

3.1. Based on Local Routing Congestion Information Flow Mechanics

The model of graph G = (V.E) to represent the network. Assume that G is an undirected connected graph, there are N nodes and M edges, one of them $V = \{e_i \,|\, i = 1, 2, \cdots, N\}$ represents a collection of nodes. $E = \{e_j \,|\, j = 1, 2, \cdots, M\}$ is on behalf of the collection. This model inspired in real communication network system. Such as on the Internet, as a result of the creation and depletion of bits of information, the number of packets associated with the network traffic is changing with time, its 屮, arrived at the destination node removal called disappear. Take an examination of the tiger, will I on a given network flow mechanics model is as follows: assume that each time step, the probability of each node to R to produce a package, and add it to the node queue, destination node in other N - 1 node 屮 random selection. Each node in transmission, the first is to search inside its neighbor nodes, if there is a destination node neighbor node, then transmitted to the destination node; If not, according to the predefined routing strategy to deliver it to the next node. Package immediately on arrival at the destination node from the complex network 屮 removed, using fifo queue rules. This contains deposit process of fire jump model enables the nodes in a network of load to given in the form of history and a drink of attack.

Different from the use of the widely used betweenness to learn righteousness node load method, This model will be the node i load is defined as $L_i(t)$ moment t in the sum of the node queue package, namely:

$$L_i(t) = L_i(t-1) + I_i(t) + \sum_j x_{ji}(t) - d_i(t) \qquad \forall i \,, \quad t \geq 1 \tag{2}$$

$$I_i(t) = \begin{cases} 1, & \beta \leq R \\ 0, & \beta \leq R \end{cases} \tag{3}$$

$$\max d_i(t) = D_i \tag{4}$$

$$L_i(t) = \frac{\sum_i L_i(t)}{N} \tag{5}$$

Among them, $I_i(t)$ denotes t time node i to produce the number of packages, $x_{ji}(t)$ on behalf of t time node j from its neighbor node i receives the number of packages, $d_i(t)$ on behalf of t time deal with a number of nodes i, node i processing capacity D_i of the said unit time to deal with the number of the parcel, k_i and < k > said node t degree and the average degree of network, $K \geq 1$ as constants, symbol $\lceil \; \rceil$ integer upwards. Formula (4) of the node processing power is proportional to the degree of the node. This is consistent with the actual network, such as in the Internet, has a large number of edge routers, tend to have more packets routed through it, at the same time, it also tend to have stronger capability to handle a packet. For simplicity, and do not break general, taking. T moment of all nodes in the network load average, said the global load level of the moment t network. In the cascading failure model of the past, because of the influence of some actual Routing protocols, such as the Internet RIP (Routing information protocol), generally defined packages from source node to destination node transmission route choice is always based on the shortest path (SP) Routing. SP strategy's capacity to make more than the shortest path only interchange nodes, with a relatively large between congestion nodes. Moreover, this strategy consider whether or

not the network in the congestion state, even if the routing performance fell sharply due to congestion by the number of nodes, that cannot be handled in time it receives packets, it can't to choose the new routing path for package. This strategy takes into account the packet to the destination node can pass all the nodes of congestion state. The global congestion awareness routing is a routing based on global congestion information. But, for the reality of large-scale network system, it is not practical in the Internet, for example, each router cannot accurately know all other real-time router congestion status. Therefore, this model defines a routing strategy based on local congestion interest.
Assume that node i in a packet to select a node in its neighbor nodes n as it's the next node to destination node j. For each neighbor node, n, define a cost function to reflect the "cost" of the distance between nodes and j, namely

$$P_n = h_{nj}(1 + f_n)^{\theta}, n \in \Gamma_i \quad (6)$$

Where h_{nj} is to the destination node j is a node n the shortest path length (minimum hop count); f_n ($f_n \in [0,1]$) is a congestion function related to node n load L_n, equivalent to node n gives a dynamic weights, the larger the value f_n, the greater the congestion degree of the node, which is the node load on the transmission efficiency is lower; Index $\theta \geq 0$ is an adjustable routing parameters, used to adjust the local congestion in the routing of the weight, the θ greater , local congestion awareness greater. Of all the neighbor node generation I get node value P_n, choose to have the smallest P_n node n as the next routing nodes. At the time $f_n = 0$, P_n is equal to that SP policy values h_{nj}. At that time $f_n > 0$, the SP strategy value is factor correction $(1 + f_n)^{\theta}$. Obviously, at that time, $\theta = 0$ local congestion did not play a role in routing, this strategy to SP.

In order to implement the proposed minimum cost path routing, each node needs to know its neighbor nodes real-time dynamic weighting f_n. Neighbor nodes f_n, the so-called local congestion information, this information on to the former is relatively easy to obtain. Internet, for example, each node can exchange keep alive with neighbor nodes continuous real-time message (keep alive messages). Consider the information transmission cost, however, can be updated every few seconds between neighbor nodes exchange information, therefore, set a time delay Δt, Δt defined as from neighbor node receives the update time steps needed for the information.

3.2 cascading failure process

In this model, make a production contract chariot rate for network load coefficient, the greater the said network load, the greater the pressure. Obviously, if R once over the network to load the biggest processing capacity, may be because of overload caused by congestion. And this paper focus on congestion (*i.e.*, the cascading failure) is caused by attack. Before the attack under normal circumstances, the network running in a state of freedom. In this state, to any node $f_i = 0$, package along the minimum cost path is the shortest path routing. When one or a few son nodes removed from the network due to attack, and the removal of general changed the minimum cost path between nodes, make originally after these nodes to reroute the package, different network load based on routing policy to redistribute. If attacked the node transmit a large load, the consequences could be serious, because the large load (or routing) need to be redistributed, and receive the load node may not be able to handle the extra load. These nodes congestion will occur, resulting in further reroute load. This is repeated, the network congestion gradually spread, resulting in a cascade of failure. In the end, the node in very small amounts of attacks can lead to the collapse of most of the network. To simulate node after being attacked network dynamic change, I will each network node congestion function f_i are defined as follows:

$$f_i(t) = \begin{cases} 0, & L_i(t) \le C_i^* \\ \dfrac{L_i(t) - C_i^*}{C_i - C_i^*}, & C_i^* \le L_i(t) \le C_i \\ 1, & L_i(t) = C_i \end{cases}, \quad (7)$$

Where, C_i^* denotes node i by flow (light load) in the upper bound of work load, since the node load fully use its ability to handle it, so we will define C_i^* as $C_i^* = D_i$ suggested by such a definition. The processing capacity of node i. The upper bound of the work in free flow when the node, the higher D_i there's ability to ease congestion is stronger; And I said node overloaded state of upper and lower bounds of the load, this paper defines its value is equal to the node load capacity of the I, namely node I queue to store the number of the parcel. In normal circumstances, the packet is transmitted along the shortest path, so the capacity of the node I defined through the between, namely

$$C_i = (1+\alpha)\lceil B_i \rceil, \ \forall i \quad (8)$$

The constants $\alpha \ge 0$ for tolerance parameters, betweenness B_i calculation method for:

$$B_i = \frac{1}{N-1}\sum_{s \ne t \ne i} \frac{\sigma_{st}(i)}{\sigma_{st}} \quad (9)$$

Among them, σ_{st} and $\sigma_{st}(i)$ meaning. As can be seen from the formula (7), f_i is about the node load monotonous reduction function. Such a definition that the node load wand its congestion function value (weights) for the routing and load distribution is mutual restriction: in the process of after the node has a weight change, the load on the network will be redistributed, the redistribution of load weight will affect the node. (7) to the right of the three conditions of the nodes is presented three states: normal, congestion and overload state. In the first two state of nodes are collectively referred to as the overload node. In most of the past cascading failure model, the node once overload, immediately as failure node In many practical network system, the node degree of instantaneous overload is allowed, and node failure if caused by the cumulative effect of overload. The Internet, for example, an accidental overload concurrent flow leads to a router. Although this overload node does not have the ability to receive packets (because there is no spare cache to store the packets), but may also in packet forwarding its cache. Decreases when the cache in the package, the node can also be restored to the state of overload. The transient overloads usually do not significantly influence the normal operation of the entire network. Moreover, many existing in the actual system monitoring and control measures. Once detected nodes overload, it will take some protective measures in the response time to alleviate overload. Considering this, we give a simple and more practical overload node failure determination mechanism: for each overload node set an overload duration time (just overload node at time of time = 1). If the node state of overload duration exceeds: T time step, the node for the failure. The parameter r is related with the set the response time of the network system itself, may be different in different systems. In the simulation, set up T = 4. In addition, when a node is isolated nodes, has clearly not receiving and forwarding packets, this node failure nodes should also be considered. Therefore, this model will overload state more than T time step and isolated nodes are collectively referred to as the failure of node, other nodes called the failure of nodes. In the actual routing protocols, such as the Internet RIP protocol, node failure events will be notified to the other nodes in network, receiving the message nodes will delete node routing failure is contained in the routing table, failure node so stop receiving packets. To this end, the provisions of this model, failure node will be removed from the network, only can reach the failure node is qualified to be the purpose of the package node.

Here the focus of global cascading failure is the maximum number of interface is a q % of the initial attack node. In order to measure the size of the cascading failure, that is, to measure the network robustness to resist the cascading failures, considering cascading failure propagation stability after the two Numbers: the largest scale S_G and efficiency of network connected sub graph U_G . S_G is the largest connected subgraph of network G contains the number of nodes. In order to reflect the effects of congestion on the network efficiency, unlike previous studies mostly adopted by the network definition of efficiency

$$U_G = \frac{1}{N(N-1)} \sum_{i \neq j \in G} \varepsilon_{i,j} \qquad (10)$$

Between the nodes i and j is defined as the path of the efficiency $\varepsilon_{i,j}$, for all paths between I and j, calculate the whole efficiency of path node harmonic, the maximum value is $\varepsilon^*_{i,j} = \left(\sum 1/(1 - f_k)\right)^{-1}$. For comparison, the two number respectively made a normalized processing, G 'for the attack but cascade failure in front of the network.

4. Simulation Results and Analysis

Article mainly in two typical model network: BA scale-free network and ER stochastic network simulation research on the cascading failure model, BA network with heterogeneous degree and between distribution, while the ER network, to the contrary, the degree and between distribution with no homogeneity. And compared to the ER network, BA network average path length of the smaller, this is a result of the degree of the existence of a great center node. To comparative study of the two different network zhe flapping on cascading failure behavior, using the same network size and almost the same average degree of < k >, if not specified otherwise, the value of N and k > < 150 and 4, respectively. The choice of size N = 150, which is based on two reasons: (1) a relatively small system can be seen as the backbone network, on which the simulation can get enough meaningful statistical characteristics; (2) because of the restriction of hardware conditions, as well as the time complexity of congestion function value calculation, the whole process of cascading failure for a longer running time. In two kinds of each simulation results on the web is in 10 different network instance on average more than 50 times. Every time the simulation experiment, before the attack, the network is from no load to start loading operation to t = 5000 paces, and if no overload failure nodes, can be thought of as the network at this time in the free flow of steady walking. In order to guarantee the cascading failure is the purpose of such processing is the attack itself rather than network overload (caused by excessive use. For convenience of observation of cascading failure process, below in figure 1 t = 0 to refer to the t = 5000, which refer to the network after being attacked but the moment before the cascading failure.

Figure 1-2 shows under a given R, have different BA and ER cascading failure on the network communication process. From figure 1 and 2 you can see, with different network cascade failure will occur. And, in the end the spread of cascading failure into a stable state. This is because the failure of nodes with the development of cascading failure and increased number, departs from these failure nodes in the network are beneficial to reduce the global load of network, so as to make the cascading failure propagation, be suppressed. And with different e ER networks have cascading failure will not occur. This is largely because, compared with the homogeneous network of ER in heterogeneous network of BA, biggest betweenness node to maintain the network function of the structure and function of bigger, therefore, attacks on this node is more likely to cause cascading failure. This and most of the cascade model is consistent with the results.

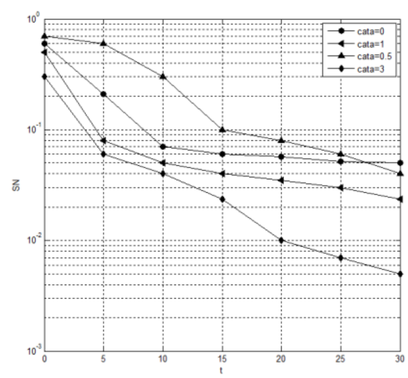

Figure 2. SN v.s. t

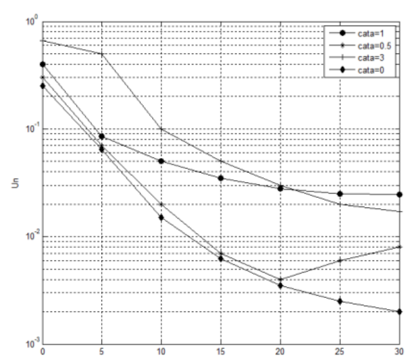

Figure 3. Un v.s. t

5. Conclusion

Complex communications and/or transportation network is essential to our life and production activities, with the continuous development of the control network, especially the rising number of users, cascading failure has become a network in a larger scale and load pressure system safety and stable operation of the serious threat. On the basis of the analysis and summary of related work, this paper proposes a with adjustable parameters based on local congestion information routing strategy, and introduce package containing "jump model, and considering an overload node failure mechanism, constructs the new cascading failure model. On the BA scale-free network and ER random discusses caused by deliberate attacks on the network of cascading failure behavior. Through numerical simulation main findings, based on the new measure network robustness index (namely, critical production rate, there is a free flow to the phase change of the cascade configuration), the optimal value of existing routing parameters to achieve most robust network and the optimal value related to the network topology. And heterogeneous BA network robustness is negatively related to the network size, the homogeneity of the ER network, on the other hand. In addition, the robustness of the two networks are negatively related to the congestion information time delay. Optimal value reveals the routing parameters, in order to improve the network robustness to resist the cascading failures, routing policy should have moderate congestion perception ability, but congestion awareness routing strategy of the stronger, the better.

References

[1] W. B. Heinzelman, A. P. Chandrakasan and H. Balakrishnan, “An application-specificprotocol architecture for wireless microsensor networks”, IEEE Trans, on Wireless Communications, vol. 1, **(2002)** October, pp. 660-670.

[2] S. Cui, A. J. Goldsmith and A. Bahai, “Energy-efficiency of MIMO and cooperative MIMO techniques in sensor networks”, IEEE Journal on Selected Areas in Communications, vol. 22, **(2004)**, pp. 1089-1098.

[3] S. K. Jayaweera, “Virtual MIMO-based Cooperative Communication for Energy-constrained Wireless Sensor Networks”, IEEE Trans, on Wireless Communications, vol. 5, **(2006)** May, pp. 984-989.

[4] W. Zhang and H. He, “Fault Tolerance for Conjugate Gradient Solver Based on FT-MPI”, Studies in Informatics and Control, ISSN 1220-1766, vol. 22, no. 1, **(2013)**, pp. 51-60.

[5] X. Li, M. Chen and W. Liu, “Application of STBC-encoded cooperative transmissions in wireless sensor networks”, IEEE Signal Processing Letters, vol. 12, **(2005)**, pp. 134-137.

[6] Y. Yuan, M. Chen and T. Kwon, “A novel cluster-based cooperative MIMO scheme for multi-hop wireless sensor networks”, EURASIP Journal on Wireless Communications and Networking, vol. 2006, **(2006)**, pp. 1-9.

[7] A. Paulraj, R. Nabar and D. Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, Cambridge, U.K., **(2003)**.

[8] S. K. Jayaweera, “Energy analysis of MIMO techniques in wireless sensor networks”, Proceedings of the 38th Annual Conference on Information Sciences and Systems (CISS), **(2004)** March.

[9] S. K. Jayaweera, “An energy-efficient virtual MIMO Communications architecture based on V-BLAST processing for distributed wireless sensor networks”, Sensor and Ad Hoc Communications and Networks, 2004 First Annual IEEE Communications Society Conference, **(2004)**, pp. 299-308.

[10] M. Dohler, E. Lefranc and H. Aghvami, “Virtual antenna arrays for future wirelessmobile communication systems”, ICT 2002, Beijing, China, **(2002)** June.

[11] M. Dohler, E. Lefranc and H. Aghvami, “Space-time block codes for virtual antenna arrays”, PIMRC, Lisbon, Portugal, **(2002)** September.

[12] S. M. Alamouti, “A simple transmit diversity technique for wireless communications”, IEEE Journ. Select. Areas. Commun. vol. 16, no. 8, **(1998)** October, pp. 1451-1458.

[13] V. Tarokh, H. Jafarkhani and A. R. Calderbank, “Space-time block codes from orthogonal designs”, IEEE Trans. Inf. Theory, vol. 45, no. 5, **(1999)** July, pp. 1456-1467.

[14] Z. Zhou, S. Zhou, S. Cui and J.-H. Cui, “Energy-Efficient Cooperative Communication in a Clustered Wireless Sensor Network”, IEEE Trans, on Vihicular Technology, vol. 57, no. 6, **(2008)** November, pp. 3618-3628.

[15] X. Li, “Energy efficient wireless sensor networks with transmission diversity”, IEEE Electronics Letters, vol. 39, **(2003)** November, pp. 1753-1755.

[16] C. Wenqing and Y. Yong, “Virtual MIMO Protocol Based on Clustering for Wireless Sensor Network”, Presented at Proceedings of the 10th IEEE Symposium on Computer Communications, Cartagena, Spain, **(2005)**.

[17] J. N. Laneman and G. W. Womell, “Distributed space-time-coded protocols for exploiting cooperative diversity in wireless networks”, IEEE Transactions on Information Theory, vol. 49, pp. 2415-2425, **(2003)** October.

[18] S. Cui and A. Goldsmith, "Cross-layer design of energy-constrained networks using cooperative MIMO techniques", EURASIP Signal Process, vol. 86, no. 8, **(2006)** August, pp. 1804-1814.
[19] A. Sendonaris, E. Erkip and B. Aazhang, "User cooperation diversity-Part I: System description", IEEE Trans. Commun., vol. 51, no. 11, **(2003)** November, pp. 1927-1938.

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