A Dependency Tree Based Improvement in Network Coding of General File System

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Abstract
In this paper, we mainly research on a dependency tree based improvement in network coding of General File System (GFS). Network coding is a technique in which transmitted data is encoded and decoded to enhance network throughput, reduce delays and construct a more robust network. Network coding has been used in many networks such as wireless sensor networks, traditional wireless networks, video multicast networks, Peer-to-Peer (P2P) networks and many others. Nowadays, with the emergence of Cognitive Radio Networks (CRNs), network coding is evolving from traditional wireless networks to CRNs. We observed that with network coding, the system is more robust and resilient to failure and provide better performance than with replication scheme to provide redundancy.
Keywords: NETWORK CODING, DESIGN AND ARCHITECTURE, GENERAL FILE SYSTEM

1. Introduction

Network coding is a technique in which transmitted data is encoded and decoded to enhance network throughput, reduce delays and construct a more robust network. Network coding has been used in many networks such as wireless sensor networks, traditional wireless networks, video multicast networks, Peer-to-Peer (P2P) networks and many others. Nowadays, with the emergence of Cognitive Radio Networks (CRNs), network coding is evolving from traditional wireless networks to CRNs. Nowadays, with the emergence of Cognitive Radio Networks (CRNs), network coding is evolving from traditional wireless networks to CRNs. Therefore in this paper, our goal is to provide a survey of network coding specific for CRNs. In CRNs, a user (called Secondary User or SU) can intelligently judge and scrutinize the environment and then make decisions to adapt transmission schemes. Thus, SUs in CRNs employ network coding for data transmission. However, since CRNs is an emerging field, therefore, many technical issues exist [1-2].

In wireless communication networks, MIMO, with the usage of multipath propagation, is an effective technology which can reduce the negative effect of wireless fading channels and improve system spectrum resource utilization and increase the channel capacity. However, the performance of MIMO system is limited by the correlations between the antennas. Furthermore in practice, MIMO is difficult to be implemented due to the restriction on user terminals of size, mass and power. Under this background, cooperative diversity is proposed, where the user terminals can share the antennas with each other to form cooperative MIMO. As a result, the single-antenna terminals can obtain MIMO performance. However, with the growing communication demands, the multiple-antenna terminal is an inevitable trend in the development of wireless communications [3].

On the other hand, network coding is another hot topic in wireless communication field. Network coding, which breaks the store and forward working mode of the traditional routers, can significantly enhance the network throughput due to expanding relay nodes' features. As a result, network coding can approach the capacity upper bound defined by max-flow min-cut theorem. We can expect that the performance of communication networks can be further improved when cooperative diversity and network coding are combined. Under this background, the dissertation makes deep studies on network coding in two-way relay channels, analog network coding, physical-layer network coding and its combining with space-time coding in multi-user cooperative communications. First, the basic principles of cooperative diversity and network coding are introduced, which are the basis of the subsequent research. In MIMO system model, combining criteria of receiving diversity and channel capacity of MIMO systems are analyzed. As well, some typical cooperative diversity methods are introduced, and the achievable rate regions and system outage probability are analyzed in a two-user cooperative model. In two-way relay channels, the two-way relay communication methods and the demodulation and mapping scheme with physical-layer network coding are elaborated. Then, the intensive research on network coding schemes in two-way relay communications is done and pseudo physical-layer network coding scheme is proposed. The signal processing procedure is analyzed. Similar to physical-layer network coding, the relay node in PPNC scheme just need one demodulation procedure and one channel decoding procedure, but without the synchronization problem. The PPNC scheme can be seen as the physical-layer implementation of network coding, and it is also a three-time slot scheme [4-5].

2. The Basic Model for Dependency Tree

From the end of last century, with the Data Mining technology maturing gradually, the research on applying Data Mining technology into fraud detection becomes one important research field. Here, the data in such type applications have the same basic attributes: massive, time-serial and unbalanced. Aiming at those attributes, Yu [6] extensively and intensively researches on the massive, time-serial and unbalanced prediction problem from four aspects: attribute construction technology, splitting measure theory, splitting measure experiment method, and the application method of Data Mining prediction model, and proposes a decision-tree-based prediction system of massive time-serial unbalanced data. Attribute Construction Technology in Data Pre-Processing Process. Three rules of the relationship consistency between attributes are proposed in Zhu's paper [7]. These rules make the condition using attribute construction in Data Mining applications standardization. The attribute relationship inconsistency problem caused by using count operators without limit is proposed in this thesis, which could build fraudulent data and make the model come from count operator invalid in the practical application in the end. Time-serial count operator based on those rules could avoid the attribute relationship inconsistency problem. To reduce the computing cost of time-serial count operator, the incremental algorithm of time-serial count operator is also proposed. To the application systems supporting incremental data, since the transaction period could satisfy the requirement incremental algorithm needed, algorithm only works a small quantity of incremental data. And this algorithm has very high value in applications. First, the purposes of the research on decision tree and the application of splitting measure. Second, the equivalence relationship between decision tree is defined, the transformability of splitting measure is proposed, and the primary form of splitting measure parameter, simple parameter matrix, is shown with the important parameter problem of impurity theory. Then, an ideal splitting measure rule, linearity distance measure rule is proposed. With the analysis, the integrated way with the effect of the splitting measures and their interests and generalized distance measure rule, which presents the mathematic commonness of all the splitting measures. And the current measure theory and family have been proven to comply with generalized distance measure rule, and the problems of the measure aiming at continuous attribute are presented. A walkthrough experiment method, which could show the attribute of splitting measures more full and profoundly, is proposed, and by these experiments the generalized distance theory is partly proved while the best splitting measure of is found. In the experiments with the most numerous splitting measures, two data construction algorithms based on simple parameter matrix and contingency table are proposed. Then by comparing the splitting measure value in various distribution, we further analyze the measure value surface, validate whether measure satisfy the minimum and maximum sub-rule of generalized distance measure rule, evaluate the computing complex of measures, test the measures with multi-split bias, test the core function with concave function, and test the measures with majority-class bias. The experiment results show that for the massive unbalanced data chi-square is better than other measures and all measures satisfy the minimum and maximum sub-rule of generalized distance measure rule. Aiming at the generic massive time-serial unbalanced prediction problem, to improve the effectiveness of data-mining applications, with the aforementioned research result, it uses hybrid algorithm of decision tree and neural network, supports the whole two-stage data-mining process, multi-level user, process visualization, on-line fraud detection with planning audit strategy, the balance strategy between audit gain and cost, the expert-accrediting multi-classifier prediction model, distributed multi-mission management and so on [8]. In this paper, we implements one decision-tree-based massive time-serial unbalanced prediction system, with the background of Customs declaration fraud detection project and the aforementioned research results.

3. The Algorithm

The master server manages and monitors the cluster activities and controls all the file system metadata, which includes: executes all operations of the namespace, control the manner of access to information, Manages the mapping from files to chunks, Knows the current locations of chunks, It controls system-wide activities like chunk lease management, Provides simpler and more reliable approach of garbage collection of orphaned chunks, Controls the migration of Chunk between chunk servers. The master server periodically exchanges Heartbeat messages with each chunk server in order to monitor its state. The three major types of metadata stored in the master are: the file and the chunk namespaces, files to chunks mapping and each chunk's replicas locations.

Consider two streams of information, both at bitrate B b/s, arrive at a node, contending for an output link, having a capacity B b/s. when network coding is used, it can be possible to increase throughput by pushing both streams through the bottleneck link at the same time. Because with network coding, the node can mix the two streams together bit-by-bit using their exclusive-OR (X0 and sending the mixed stream through the link. XOR in this case, is the function computed at the node. This increases the throughput of the network if the two streams are disentangled before reaching their final destination. Whereas with routing only, the packets are forwarded without any computation performed. Figure 1 illustrates an example of an idealized network of routers, link and computers.

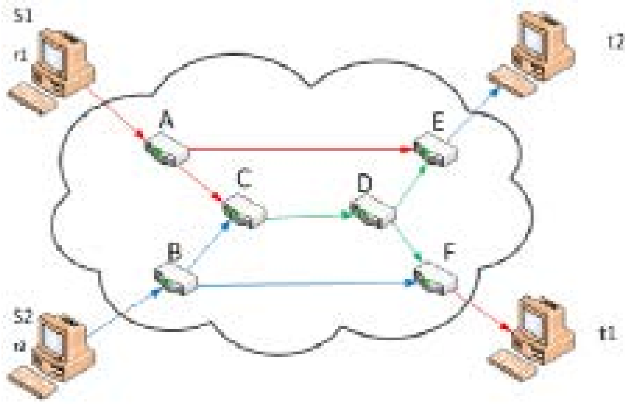

Figure 1. The example of an idealized network of routers, link and computers

The equation of basic function is as equation (1) as follows:

$$\partial_j (C_{ijkl}\partial_k u_l + e_{kij}\partial_k \varphi) - \rho \ddot{u}_i = 0 \tag{1}$$

In which,

$$\alpha^2 = \frac{\rho_0\omega^2}{C_{11}^0},\ \alpha^2 = \frac{\rho_0\omega^2}{C_{66}^0},$$

$$\beta_\perp^2 = \frac{\rho_0\omega^2}{C'_{44}},\ C'_{44} = C_{44}^0 + \frac{(e_{15}^0)^2}{\eta_{11}^0} \tag{2}$$

The first one is the function for random dynamic systems in the form of:

$$\left[\frac{1}{c^2}\left(\frac{\partial}{\partial t}+\varepsilon\right)^2 - \Delta\right]\bar{g}(r,t) = \delta(t)\delta^2(\mathrm{r}) \tag{3}$$

Another function is defined as:

$$\left[\frac{1}{c^2}\left(\frac{\partial}{\partial t}+\varepsilon\right)^2 - \Delta\right]\left(\frac{\partial}{\partial t}+\varepsilon\right)^2 \bar{h}(r,t) = \delta(t)\delta^2(\mathrm{r}) \tag{4}$$

$$\bar{h}(r,t) = \int_{-\infty}^{\infty} f(t-\tau)\bar{g}(r,\tau)d\tau \tag{5}$$

In which, $f(t)$ is the corresponding function defined as the following (19):

$$\left[\frac{\partial}{\partial t}+\varepsilon\right]^2 f(t) = \delta(t) \tag{6}$$

After $\bar{g}(r,t)$ is obtained, $\bar{h}(r,t)$ can be easily obtained from Equation (18). So, we have:

$$\bar{g}(k,t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \frac{e^{-i\omega t}d\omega}{k^2 + (\varepsilon - i\frac{\omega}{c})^2}$$
$$= c^2\Theta(t)\frac{\sin(ckt)}{ck}e^{-\varepsilon t} \tag{7}$$

$$\bar{g}(r,t) = \frac{1}{(2\pi)^2}\int e^{-i\mathrm{kr}}\bar{g}(\mathrm{k},t)d^2k \tag{8}$$

Via Equation (20), (21) can be converted into:

$$\bar{g}(r,t)=\Theta(t)\frac{c}{(2\pi)^2}\int_0^{2\pi}d\varphi \int_0^{\infty}\sin(k[ct-kr\cos\varphi])dk \quad (9)$$

In the equation, the following property is adopted:

$$\int_0^{2\pi}\sin(kr\cos\varphi)d\varphi=0 \quad (10)$$

For defining, we normalize it

$$\int_0^{\infty}\sin k\lambda dk=\lim_{\varepsilon\to 0+}\int_0^{\infty}e^{-\varepsilon k}\sin k\lambda dk =\lim_{\varepsilon\to 0+}\operatorname{Re}\frac{1}{\lambda+i\varepsilon} \quad (11)$$

Thus, (22) can be represented into:

$$\bar{g}(r,t)=-\frac{c\Theta(t)}{(2\pi)^2}\operatorname{Re}\int_0^{2\pi}\frac{d\varphi}{r\cos\varphi-ct+i\varepsilon} \quad (12)$$

Thus, Equation (25) can be represented as:

$$\bar{g}(r,t)=-\frac{c\Theta(t)}{(2\pi)^2}\frac{2}{r}\operatorname{Re}\int_0^{2\pi}\frac{e^{i\varphi}d\varphi}{e^{2i\varphi}-2\cosh\phi e^{i\varphi}+1} =-\frac{c\Theta(t)}{(2\pi)^2}\operatorname{Re}\frac{2}{ir}\oint_{|s|=1}\frac{ds}{s^2-2\cosh\phi s+1} \quad (13)$$

When a read request from the application is made for a file, the client translate the request form (file name, and byte range) specified by the Application into chunk index within the file and then, sends a request to the master that contains the (file name and the chunk index) to get the location of the chunk servers storing the data. The master sends a reply with the chunk handle and the replicas locations (i.e. chunk servers where the replicas are stored). The client caches this information using the file name and chunk index as key. The client picks a chunk server randomly from the lists of servers offered by the master then sends the request containing (chunk handle, and the byte range) to the replica location(i.e., the chosen chunk server). The chunk server sends the requested data to the client. The client then forwards the data to the application.

This read request is applied in the two schemes; network coding and replication, knowing that the data are stored in the various chunk servers and the read process is random.

The chunks read from the chunk servers will determine the number of transmission the request will do. Hence it will also determine the average bandwidth. The action between the client and the master server to get the metadata of the file is considered already done in this case. This means the client server knows the location and chunk index of the data. It also knows the location of each chunk server storing the coded chunk data.

When the client receives the data sent from the chunk servers, it will check to see if the data is the same as the one it requested. If it is different the client will resend the same request until the correct chunk data is received. This process is repeated until the correct file data is obtained. Then an average value from the number of transmission required to get the correct data is calculated to find the bandwidth in the two schemes network coding and replication.

To solve the problem of transmission delay in a multi-user cooperative system, analog network coding is introduced to a multi-user cooperative system, and a cooperative analog network coding scheme is proposed. The cooperation procedure of this scheme is analyzed and the channel capacity of the scheme is derived when the relay node works in amplify-and-forward mode. Compared with traditional cooperation, the influence of the nodes' antenna number on channel capacity is analyzed and the BER performance of cooperative analog network coding is studied under different simulation scenarios. After that, the problem about how to apply physical-layer network coding into multi-user cooperative systems is deep studied. Employing polarization diversity, cooperative quadrature physical-layer network coding scheme is proposed and the cooperation procedure is analyzed.

4. Simulation Results and Discussion

A. The experiment is focus to measure two things:

1. The error rate of the system versus probability of failure for two storage system schemes

2. The average bandwidth in terms of number of retransmission required to recover the original data for any pair of chunks that fails with network coding and replication storage scheme.

B. setup

The simulation tool used is matlab.

Simulation setup:

Two data fragments (A and B) and four different chunk servers.

The data stored across the chunk servers with network coding:

Chunk server 1: chk A

Chunk server 2: chk A+B

Chunk server 3: chk B

Chunk server 4: chk A+2B

The data stored across the chunk servers with replication:

Chunk server 1:chk A

Chunk server 2: chk A

Chunk server 3:chk B
Chunk server 4: chk B
Number of data (bits) is 10

The simulation results are averaged of 10000 samples. The choice for having only fragments A and B, distributed into 4 chunk servers only, is because we felt it will bring out the best in our experiment since the simulation tool used is not optimized for complicated network coding nodes e.g. OM net, ns-2, considering it's just a comparative approach. Figure 2 shows average bandwidth in terms of number of retransmission as a function of the probability of failure of chunks.

Conclusions

In this paper, we mainly research on a dependency tree based improvement in network coding of General File System (GFS). From the end of last century, with the Data Mining technology maturing gradually, the research on applying Data Mining technology into fraud detection becomes one important research field. Here, the data in such type applications have the same basic attributes: massive, time-serial and unbalanced. The chunks read from the chunk servers will determine the number of transmission the request will do. Hence it will also determine the average bandwidth. The action between the client and the master server to get the metadata of the file is considered already done in this case. This means the client server knows the location and chunk index of the data. It also knows the location of each chunk server storing the coded chunk data.

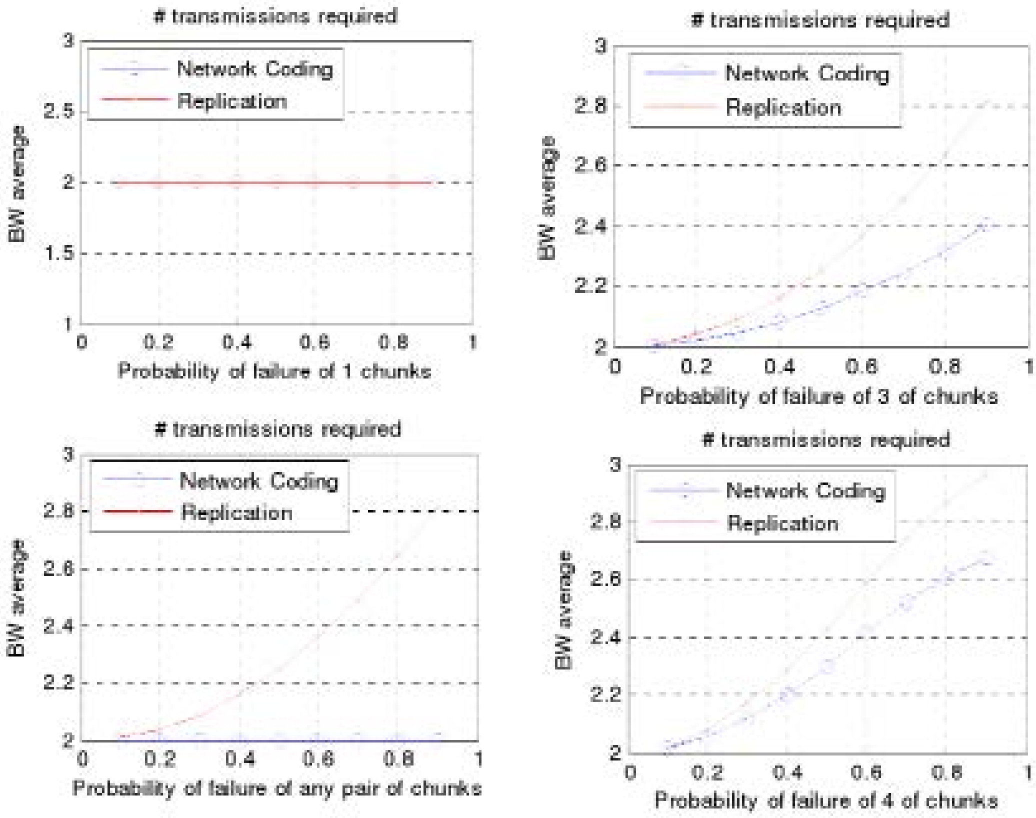

Figure 2. The average bandwidth in terms of number of retransmission as a function of the probability of failure of chunks

To solve the problem of transmission delay in a multi-user cooperative system, analog network coding is introduced to a multi-user cooperative system, and a cooperative analog network coding scheme is proposed. The cooperation procedure of this scheme is analyzed and the channel capacity of the scheme is derived when the relay node works in amplify-and-forward mode. Compared with traditional cooperation, the influence of the nodes' antenna number on channel capacity is analyzed and the BER performance of cooperative analog network coding is studied under different simulation scenarios.

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