Study on the Distributed Routing Algorithm and Its Security for Peer-to-Peer Computing

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By virtue of its great efficiency and graceful architecture, the Client/Server model has been prevalent for more than twenty years, but some disadvantages are also recognized. It is not so suitable for the next generation Internet (NGI), which will provide a high-speed communication platform. Especially, the service bottleneck of Client/Server model will become more and more severe in such high-speed networking environment. Some approaches have been proposed to solve such kind of disadvantages. Among these, distributed computing is considered an important candidate for Client/Server model.

As one of special distributed computing, the Peer-to-Peer (P2P) computing employs the features of distributed computing to achieve resource sharing directly among peers. The feature of free of central controlling and management makes it suitable for building application in NGI. P2P also has some similarities with grid computing. Regarded as a novel application model, P2P is a valuable technology for the wired Internet, wireless network and ad hoc networks. Therefore, the researches on P2P and its application are becoming a new highlight in not only distributed computing field, but also the whole information fields.

While shifting from central Client/Server to fully distributed P2P, the routing algorithm plays an important role. It does figure out the method to build a connected P2P network and open a communication link for each peer. However, lacking centralized server makes the routing in P2P have many differences from the IP routing in TCP/IP network. The waste of networking resources and the inconvenience of “anarchism” in the flooding routing of the first generation P2P make it only suitable for small-scale application. Likewise, the rigorous architecture and no consideration about specific requirement of application of the distributed hash table (DHT) routing drop the shadow on the second generation P2P, which relies on the DHT. Because of no considerations about the importance of security, the second generation P2P is also limited to particular application areas. Hence, research on the distributed routing algorithm in the next generation P2P is an open question in IT.

On the background of P2P, the routing mechanism and its related secure issues are explored in this paper. The main results include:

1) Propose a community sensitive distributed routing (CSDR) algorithm. The method is simple, fully distributed, applicable, and provable correctness. The CSDR algorithm consists of peer adding, peer deleting, community initializing and information updating. The connectivity of CSDR network is also proved. The application case study shows this routing mechanism is helpful to build an interconnected P2P network.

2) Propose a new bidding-electing algorithm. A novel bidding-electing function, exponential module based bidding electing function, is proposed. The fairness, correctness and probability of success are argued. A multi-winner bidding-electing algorithm suitable for CSDR is also designed. This electing algorithm is based on ring topology and can be used to elect more than one winner. The details about how this algorithm can be used in CSDR to elect community eyes (CE) are also presented.

3) Propose a one-way accumulator based peer authentication solution. Analyzing the foundation of one-way accumulator shows that this technique is usable to the peer authentication in CSDR. Two accumulators are designed and analyzed. Then, three peer authentication protocols are also presented. The conclusions show the accumulator based scheme can reduce the secure incidents in CSDR based P2P network, especially in its routing process.

4) Propose some new P2P application models. By integrating the requirement of security with the “floating” feature of P2P network, a structured secure P2P model is presented. Based on this model, the new architecture of P2P is also addressed. Then, three novel application models are brought forward too. The PKey, P2P based distributed key management system, is a substitute for distributed CA or other public key
infrastructure. The PStore, P2P based storage system, is a prototype that can be used to store and retrieve information in P2P environment. The BWFEP, P2P based fair exchanging protocol, is helpful to exchange resource between two peers impartially.

Key words: peer-to-peer computing; P2P distributed computing; information security; distributed routing algorithm; bidding-electing algorithm; one-way accumulator

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The fast development of modern electronic warfare, broadband high power array radar system, high power jammer and microwave directional power weapon imposes high demand on high power microwave resource. With such features as high power, broadband, multi-mode, etc., traveling wave tubes (TWTs) play an important role in the high power microwave amplifiers. Since the slow-wave system is the core of beam-wave interaction in TWTs, the function and performance of it directly determine the capability of the TWTs.

The author of this thesis fulfills a comprehensive analysis in the high-frequency properties of the slow-wave system of TWTs (with helix as an example) and the slow-wave system of the relativistic TWTs (with disk-loaded waveguide as an example) by such methods as theoretical analysis, computer simulation and experiment. In addition, a new kind of rib-loaded disk-loaded waveguide is put forward along with a thorough analysis of the influence on the characteristics of the disk-loaded waveguide by the plasma injection. Furthermore, the nonlinear characteristics of relativistic TWTs are also touched upon; on the other hand, some experiments have been carried out on the dispersion characteristics of the disk-loaded waveguide. All in all, the innovative theoretic methods and computer simulation methods adopted on the study of the slow-wave structure of TWTs and relativistic TWTs provide theoretical support for the design of the slow-wave structure of the TWTs.

The main achievements and innovations of the thesis can be concluded as follows:

1) Although the symmetry TM01 mode is the main mode, research about the asymmetry mode of disk-loaded waveguide is necessary. Considering the asymmetry mode, the general dispersion equations and interaction impedance expressions of disk-loaded waveguide are obtained through strict field theory. Based on these, the practical disk-loaded waveguides are designed, which can be used in relativistic TWTs.

2) Based on the Maxwell equations, the basic equation of the slow-wave structure filled with plasma in the finite magnetic field is deduced. The dispersion equation and interaction impedances of the disk-loaded waveguide filled with plasma are studied in the strong longitudinal magnetic field for the first time, which proves that the frequency of the TM01 mode upshifts and interaction impedance increases as the density of the plasma increases. When a periodic structure is loaded with plasma, the spectrum of the trivelpiece-gould (TG) modes will become abundant. As the plasma density increases to a large scale, it also can be found the TM01 mode of the disk-loaded waveguide overlaps the TG mode. These two modes couple with each other and form the new hybrid modes G1, G2.

3) The author improves the method to calculate the axial periodic waveguide by expanding the slow-wave structure's boundary function in Fourier series, which can be adopted in not only the axial periodic waveguide but also the azimuthal periodic waveguide. Furthermore, the general dispersion equations, which can be used to analyze the axial and azimuthal periodic waveguide, are deduced in the thesis.

4) A new rib-loaded disk-loaded waveguide is presented in the thesis, together with the analysis into the dispersion characteristics and interaction impedance. The loading of rib can improve the bandwidth of the disk-loaded waveguide, which can be
applied to the relativistic TWTs in the future.

5) Taking the radial thickness of the helix into account, the finite size vane model for the vane-loaded helical slow-wave structures (SWS) is suggested in the thesis for the first time. The expressions of dispersion properties, interaction impedance and attenuation constant of this model are derived, by which two vane-loaded helical slow-wave structures of the traveling-wave tube are calculated. It is interesting to find that the center angle ($2\theta$) of the vanes has optimal value when the phase velocity is minimum by the theoretical analysis.

6) With consideration of the radial thickness of helix, the tape helix model is suggested for the vane-loaded helical slow-wave structures. By taking the discrete supports bars into some continuous dielectric tube regions, the dispersion equations and the expressions of interaction impedance and attenuation constant are obtained. The calculated results accord with measured values very well. Compared with measure values, the model that takes the radial thickness of helix into account can increase the calculative accuracy of dispersion properties.

7) By the electromagnetic software HFSS and MAFIA, the three types of slow-wave structures are simulated, which proves that although based on different basic theories, both electromagnetic codes are capable of simulating eigenvalue problems of slow-wave structures of traveling wave tube.

8) Based on the theory of mode expansion, the self-consistent working equations of nonlinear beam-wave interaction of the relativistic TWTs have been obtained. The three-dimensional nonlinear characteristics of the X band relativistic TWTs are analyzed with the self-consistent working equations.

9) A broadband and a narrowband disk-loaded waveguide for the relativistic traveling wave tube are designed. The "cold test" of the waveguide is carried out with the resonance method, and the simulation results accord with measured values very well, which testifies the reliability of the theoretical analysis.

Key words: traveling wave tube; disk-loaded waveguide; helix; slow-wave structure; dispersion characteristics; interaction impedance; plasma filled; computer simulation; rib-loaded; hybrid mode

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Research on Signal Processing Arithmetic of Subsurface Ground Penetrating Radar

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Ground penetrating radar (GPR) is an impactful detection method of buried targets developed in these decades and has been broadly used in the world. Compared with other detection method, for example, resistivity, EMI and seismology, the GPR has many advantages. For this reason, the GPR is always one of the researching hotspots in the world in these years and has become an important branch of remote sensing. Although the design of GPRs is very complex and difficult, the demands of applications from different fields are continuously increasing. It is obvious that the research of GPR is very significant for the development of civil economy.

The research of GPRs for middle and deep applications has been comparatively mature. But many problems about GPR for short applications are still to be researched deeply. Especially in China, there are no research reports about GPR for short application.

In this dissertation, the signal processing algorithms of GPR for short application is studied. The research emphasis is put on the precise evaluation of wave speed in medium, clutter reduction, synthetic aperture processing algorithms (SAPAs), stepped frequency GPR, the effect of wave speed error for SAPAs et al.

The main results of this dissertation can be concluded as following:

1) On the basis of the signal features of subsurface penetrating radar, the extraction of edge contours which uses zero-crossing points and others traditional methods is discarded. The method of extremum is given for extraction of edge contours. The edge contours of the targets can be extracted more accurately using the method of extremum and generates less data for Hough transform. According to the analysis of Hough transform and the deficiency of traditional Hough transform, an improved Hough transform is proposed in which a FIR low-pass filter is added to improve the accuracy of Hough transform.
The improved Hough transform has performances better than the traditional Hough transform by the evaluation for the practical data.

2) On the basis of the signal features of subsurface penetrating radar, an effective method of eliminating ringing effect for GPR is given. And it can improve the resolution of GPR.

3) When using synthetic aperture processing based on Kirchhoff migration for subsurface GRR, the signal to noise ratio (SNR) of the image is very low. The author proposes one modified SAPA based on Kirchhoff migration for improving the SNR of the image. The processing result of practical data is also given.

4) It is very difficult to scale the azimuth resolution of GPR. The author gives one method of scaling the azimuth resolution for subsurface GPR. And the simulation result is also given.

5) Various SAPAs are applied for subsurface GPR. The analysis and comparison show that SAPAs based on holographic imaging and Stolt migration are better for subsurface GPR.

6) Based on the scaling azimuth resolution method given by the author, the effect of wave speed error for SAPAs based on holographic imaging is given. The relative curve between wave speed error and azimuth resolution is given.

7) Based on the scaling azimuth resolution method given by the author, the effect of wave speed error for SAPAs based on Stolt migration is given. The relative curve between wave speed error and azimuth resolution is obtained.

8) Because continuous wave stepped frequency radar has higher average power and relative bandwidth, it has been comprehensively applied with better azimuth resolution and penetration depth in ground penetrating. The author researches the fundamental of SFCW-GPR. The SAR processing result is also given. And the author gives one synthetic aperture processing solution based on curve fitting.

Key words: ground penetrating radar; synthetic aperture imaging; clutter reduction; stepped-frequency continuous wave ground penetrating radar; hyperbola; azimuth resolution; synthetic aperture radar

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Preparation of 3 Inch Double-Sided YBa$_2$Cu$_3$O$_{7-x}$ High Temperature Superconducting Thin Films

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Owing to its excellent electrical property, YBCO thin film is much better than metal in the application for microwave devices. It makes the devices smaller, lighter, and with higher quality factor and lower insertion loss. YBCO thin film has attracted attentions for many years. Aiming at the uniformity and property of 3-inch double-sided YBCO thin film, the following aspects is considered in this dissertation:

Different deposition methods are compared on the equality of both sides of double-sided thin films. A single inverted cylindrical sputtering (ICS) combined with substrate rotation is used to deposit double-sided YBCO films simultaneously for ensuring the equality of both sides. In comparative research on the substrate rotation modes, such as different in-plane rotations, and out-of-plane rotation, a novel one-axis-driving biaxial rotation has been invented by way of ingenious clamp changing. This rotation mode is simple and reproducible. As it combines out-of-plane rotation with in-plane rotation together, the biaxial rotation gives a good opportunity to simultaneously deposit large-area double-sides YBCO thin films. For boosting the deposition rate, two ICS guns are used to deposit films. The deposition rate is increased to 1.0 nm/min from 0.3 nm/min for each side of 3-inch double-sided YBCO thin films.

In the simulation of film thickness distribution, films deposited with ICS are investigated systematically. The thickness distribution of large-area films can be studied in both directed and diffusive transfer modes by way of target-end projection and twice source-transformations, respectively. The results show that the target length has little effect on the thickness homogeneity. Deposited with biaxial rotation, the films have good thickness distribution. Rotation rate modulation in biaxial rotation can improve the film thickness distribution further, with deviation
falling down to only 5%. Beside of the thickness, the biaxial rotation has been proved to be suitable for ICS deposition of multi-composition oxide large-area double-sided thin films with homogeneous composition distribution, less than 5% deviation within 3-inch. In addition, the biaxial rotation is useful for other-shape deposition sources for increasing the film uniformity, especially for conic sputter gun.

On the film growth mechanism, the film morphologies at initial stage, their evolutions in deposition process, and the morphology variation with deposition temperature and deposition rate are probed. The results show that, in the range from 760 °C to 820 °C, the deposition temperature has obvious effect on the morphology but little on crystalline orientation. Due to the substrate inducement, in a relatively wide deposition temperature range, all the crystalline grows with c-axis perpendicular to the substrate surface. A much higher deposition temperature generates the clusters form large-size islands, such as needle-like crystalline on LaAlO$_3$.

Through systematically research on the deposition parameters, optimized parameter range has been obtained, viz. total pressure ranging from 30 Pa to 35 Pa, ratio of Oxygen to Argon being about 1:2, deposition temperature being 810 °C, target-to-substrate distance being 60 mm. The self-template process, namely deposition at 20-50°C higher than the normal deposition temperature for 1 or 2 hours followed deposition at 10-30 °C lower than the normal deposition temperature, can improve film crystal structure (FWHM$_{605}$ down to 0.28° from 0.4°) and microwave property ($R_{S145GHz, 77K}$ down to 0.35 mΩ from 0.89 mΩ).

By optimizing the deposition parameters, 2-inch double-sided YBCO thin films have been deposited with biaxial rotation, its $T_C$ being 89K, its $R_{5145GHz, 75K}$ ranging from 20 to 50 mΩ. With rate modulated biaxial rotation, homogeneous 3-inch double-sided YBCO thin films have been deposited. Its $T_C$ is ranged from 89.8 to 90.2K, $J_C$ is ranged from 2.5 to 2.9 MA/cm$^2$, and $R_S$ is ranged from 50 to 75 mΩ at 145 GHz, 75K. At 8.5 GHz, 77 K, the average value of $R_S$ is about 0.6 mΩ. The films have been used by different users in small scale for fabricating microwave devices, such as resonators, filters. The good performance of such devices testifies that the films could meet the microwave devices demands.

Key words: YBCO; double-sided thin films; epitaxial growth; homogeneity

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