Structure:

1. Motivation
    a. Preview

With appearing and developing of the Internet, spreading over the world for many enterprises became possible. Enterprises have a possibility to open branch offices that are far from head office. For example “Intel” has more than 83900 employees in 48 countries in over than 294 offices.

Unfortunately, bigger distance between main data server and branch office, also rapid growth of the data amount – all these cause incredibly high IT-costs, technical problems that develop into malfunction of data security, integrity and, of course, uncomfortable use for employees on both sides: branch office-side and in the main office-side. The technical side of the problem is that existing protocols and other techniques that were designed mainly for low-delay networks. For example, CIFS and TCP were designed for communication over LAN, what means that these protocols work in low-delay nets.

Of course, as soon as such problems were found out, different solutions appeared. But all these things solve only concrete tasks – not the whole task of comfortable work over WAN. The conflict between security, consolidation, integrity of the data and users need for comfortable and fast access required integrated and simple solution.

So, the market of WAN-optimization appeared. And in the year 2005 Wide Area File System (WAFS) was announced as a product that integrates the most successful decisions.

2. Features
    a. WAFS is…

Simple explanation of what WAFS is gives as Wiki: “WAFS products allow remote users to access and share files globally at LAN-like speed over the WAN. Distributed enterprises that deploy WAFS-solutions are able to consolidate storage to corporate datacenters, eliminating the need to back up and manage data that previously resided in their remote offices. WAFS use techniques such as CIFS and MAPI protocol optimization, data compression, and sometimes storing recurrent data patterns in local cache”. [Wikipedia]

Obviously, there are many different “versions” of wide area file system. They differ from one manufacturer to the other and, of course, the set of techniques could be really various, depending on manufacturers’ technical and monetary resources.

In the following chapter two most common WAFS architectures are presented and the most common and simple set of used techniques is shown.

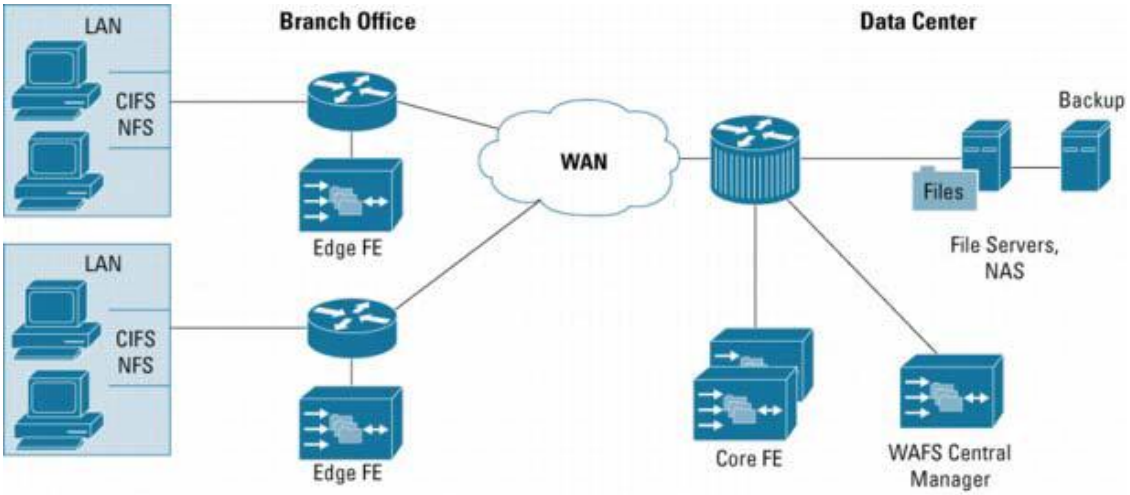
    b. The most common Architecture

As already mentioned, two topologies will be shown here: an architecture of Cisco WAFS and an architecture of Brocade Tapestry WAFS.

These two manufactures were chosen because their products are pretty simple in use, simple to deploy and understand d its work, what means comfortable managing for IT and no difficulties for

personal; also these enterprises are rated high – it could be a sign of high quality and consumers tolerance.

On the following picture you see the topology of Cisco product. It is built on one device called File Engine that can perform 4 different roles, depending on downloaded software: Edge File Engine (EFE), Core File Engine (CFE), WAFS Central Manager and WAFS File Replicator.



Pic. 1. Cisco WAFS topology.

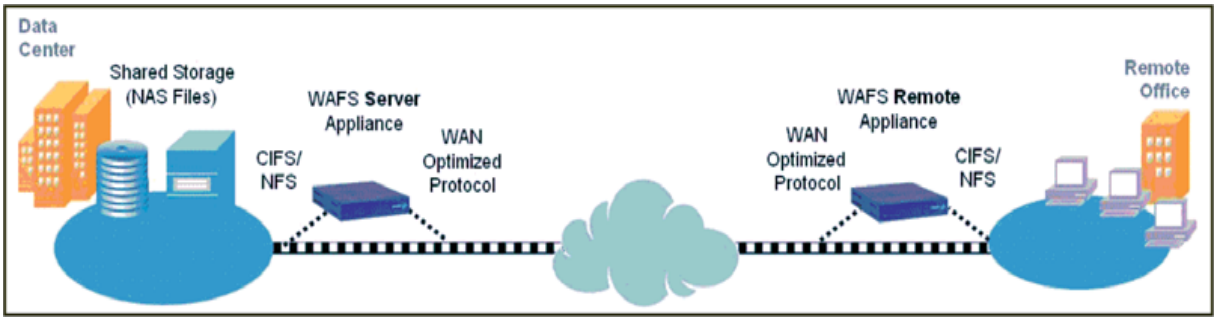
Edge File Engine (EFE) is deployed on the side of branch offices and substitutes local file servers and print-servers.

Core File Engine (CFE) is deployed in the central data office.

Two remained components are temporal and are used for customizing and data transporting. As already said above, one device is used, but different software is downloaded, so one gadget can perform three functions at once: Core FE plus Central Manager plus File Replicator or instead of Core FE Edge FE could be used.

One EFE can serve up to 150 computers and at the same time one CFE can serve up to 4000 computers connected over EFE. So, totally about 60000 elements are connected in one high-speed net.

On the second picture you see the architecture of Brocade Tapestry WAFS.



Pic. 2. Brocade Tapestry WAFS topology.

It looks almost like previous picture but without temporal elements. This topology consists of two components: WAFS Server Appliance (also called Data Center Node), which is deployed on the side of the head datacenter and WAFS Remote Appliance (Branch Office Node), which, as you can guess, is deployed on the branch office side. In this solution Server Appl. Works as the gateway for Remote Appl. and serves up to 4000 Branch Office Nodes. Each Remote Appl. can serve about 150 users. As the result the same quantity of elements is connected as in CISCO decision.

Each appliance communicates with PCs via standard protocols making no difference for employees while working. To communicate with each other, appliances use optimized protocols and use additional techniques.

c. Commonly used techniques.

As was already mentioned, Wide Area File System is the product that integrates different techniques and solutions existing on the WAN-optimization market. First of all need to mention: there exist a most common set of solutions used in product of every enterprise. And, of course, there are wide variety of additional algorithms and techniques, which differ from one product to the other. In this paper only common set will be discussed. If you want find out additional information about certain product, would be better to search for it on the official manufacturers' web site.

The most common set of solutions used in WAFS technology is:

1. Smart cache;
2. Protocol optimization;
3. Channels' bandwidth optimization;
4. Data integrity.

Smart cache

Under "Smart cache" principle "cache everything that could be helpful in the future" could be assumed. First of all, this is caching of the data: Everything goes locally. Whole files, changed parts and metadata – everything is cached on both sides to speed up the work by reducing the impact on the channel with lower dataflow.

Let's see how caching works in common. To avoid uncertainties with file-versions WAFS allows asynchronous access to the file located on the main data server. When remote user opens the file on his computer, the main exemplar is locked on the other side. After save-close operation only changed part is locally cached and sent to the main server. This practice reduces the traffic load on the channel and, of course, response time is also decreased. Also, in Edge Appliance files are grouped into different frames and sent at once, accordingly to that the band is less loaded in certain period of time.

Protocol optimization

Caching is used not only on data, but also in protocol optimization. As was already mentioned in the beginning of this paper, common protocols, like RPC, TCP etc. were designed for low-delay nets. Over WAN such protocols bring many problems. It occurs because of the way they work: For example TCP while working to conduct the file sends many acknowledgment requests and responses; breaks data

into chunks and send it in turn – complements too many steps. Each step requires pretty much time. If one package is missed the transmission starts from the beginning with sending new acknowledgments. To solve these problems common techniques are used:

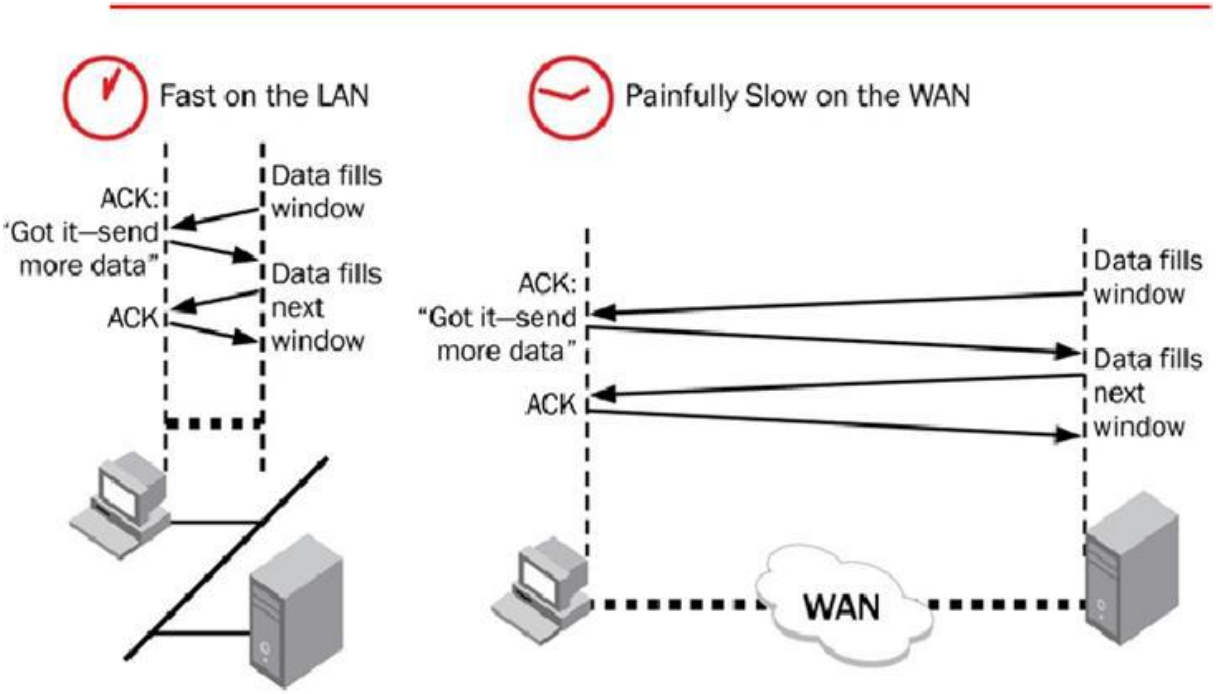
1. Write Back caching;
2. Read-ahead-technique and forecasts algorithms;
3. Caching of negative answers.

Write Back – is the method of reverse entry, when a content of core storage is only than updated, when the whole data block from the cache-memory is written down. It means that processor doesn't appeal to core storage for some period of time. Accordantly, during the work process, at first, data is written into high speed cache, and when the system is less work loaded, data is written to RAM.

Read-ahead-technique and forecasts algorithms are used to predict the behavior of RPCs' acknowledgments. Following happens: forecast algorithm basing on the past experience predicts following (next) acknowledgment, sends it instead of real acknowledgment and continues the answers' chain based on predicted element.

Caching of negative answers works similar to Read-ahead-technique and forecasts algorithms. As you know, when negative answer (acknowledgment) is got, the chain of request starts from the very beginning. But this "talk" is already cached on both sides of the system and is downloaded faster instead of the real "communication". Such solution reduces the latency.

Another way to optimize common protocols is to use "TCP Acceleration". On the following picture you see time difference (performance) between work over LAN and WAN.



Pic.3. TCP performance in a LAN vs. a WAN

Earlier was mentioned that TCP send many acknowledgments, what hampers the "communication" between pcs. Now we add that TCP also utilizes a sliding window mechanism to limit the amount of the data in a flight at any time. While sending acknowledgments over WAN the size of the window is

never stable: in case of positive response, the size increase; in case of negative response the size of sliding window decrease more times as increase. Unfortunately an average size never reaches optimum.

In many existing WAFS products another, modified protocol is used, it is called "Storage Caching over IP (SC/IP) protocol". It differs from previously used TCP in sliding window mechanism – it is larger than "original" one and is stable size. Also the pool of connections (at the same time more than one communications' sessions are held) is established, what gives an ability to send more data blocks at once.

All these features allows to reduce the impact on the channel and decrease the response time – that results in more comfortable work for employees with the files are situated on the main data server.

Channels' bandwidth optimization

Wide Area File System solutions also use techniques to deal directly with communication channels bandwidth:

1. Requests' priorities;
2. Restrictions for band use;
3. Packages compression.

To make communication channels better (higher efficiency) WAFS solution uses priority of use and restriction. For example, when special software is installed on main data server and downloaded on remote gadget over WAN (the application is used remotely, could be run directly from the applications server, or from the main server of the company) – only part of the channel is given especially for this operation. But if something happens and the bandwidth drops, less significant processes will be stopped to complete processes with high priority.

Also WAFS transforms the amount of data to work more efficiently, with the help of different reduction and compression techniques the size of data flow sent over WAN is reduced badly.

By streaming files with compression over the WAN following happens:

At first, when a file from the main server is asked, it is broken into packages and is sent over WAN to the branch office node, where as soon as first package is arrived, buffering begins. As soon as the first package is buffered the work with the file can be started.

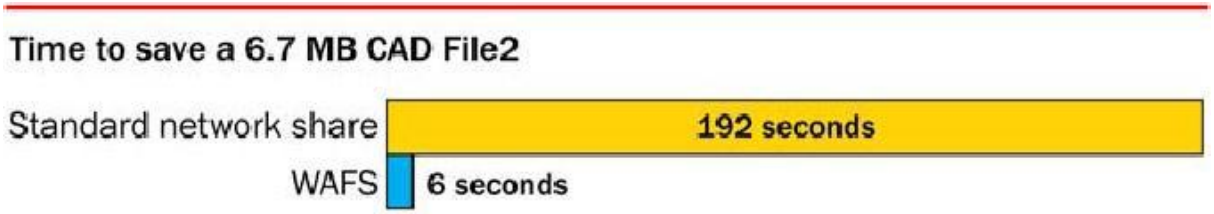
Another very interesting solution is so called "dictionary based compression", it reduce data on the wire at the stream level for all TCP protocols. New data streams are catalogued and assigned a tag on both nodes at either end of connection. When the sender attempts to transfer the same data stream again, much smaller data amount – tag, is sent instead. On the other end tag is used to index locally held data in the dictionary; and then the original data stream is downloaded from the local cache.

3. Summary

To sum everything up need to remind, that WAFS is designed for big enterprises spread over two or more countries. It consists of different WAN-optimization techniques and other solutions. The WAFS products of different firms could be totally different, but almost every decision uses common set of techniques: Smart cache, Protocol optimization, Channels' bandwidth optimization and Data integrity.

The results are really impressive: on one hand the IT-costs for keeping servers, IT-staff in every remote office decrease; on the other hand the work with data became safer, there are less errors and problems while working with files or with special software. And for simple employees almost nothing changed in a view, but speed of the download increased.

On the following picture you can see the difference in time between works over simple WAN and work over WAN with the help of WAFS.



Pic. 4. Time difference for saving a file

So, you see that this technology is effective for now, taking into account the level of technical achievements. Perhaps in near future other solutions could me more popular, or WAFS itself will change.