Trends in Computing and Communication

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***Abstract*— now days computing and communication technologies are changing drastically. Even latest technologies are very efficient in terms of power consumption and computing power but we cannot avoid earlier technologies, which have been proven. Whenever we think about rugged and MIL-STD application, still things need to be proved.**

This paper has been divided into 2 section in the 'first section', I am discussing about High Performance Computing (HPC), GPU and Cloud computing and combination of these which has been used to perform computation intensive task. Section II discuss about wireless communication in missiles and its challenges.

Keywords- High Preformance Computing; Wireless Communication; Cloud Computing;

I. HIGH PERFORMANCE COMPUTING

Large scale of computing systems usually referred as High Performance Computing Systems or Supercomputers have been used worldwide for solving computation intensive and number crunching application. Some of these applications include computation fluid dynamics (CFD), structural analysis, weather forecasting, quantum simulation, seismic data processing, cryptanalysis, nuclear explosion simulation, and simulation of other very complex phenomenon.

A. GPU computing

Graphics device companies developed GPUs as a specialized circuit to accelerate the process of building computer graphics on computer monitor screens. GPUs are widely used in personal computers, mobiles phones, computer workstations, and embedded system. They have distinguished parallel computing ability due to their parallel structure with many cores working together to process large volumes of computer graphics pixels. Because of this, researchers began to use GPUs for scientific computing. However, they had to map their application into problems that draw graphs and program with graph programming languages such as OpenGL and Cg.

Nvidia realized the potential to use GPUs for general-purpose computing and developed the General-Purpose GPU (GPGPU) and Compute Unified Device Architecture (CUDA). With CUDA, researchers can develop GPU parallel application easily with high-level languages such as C, C++, and FORTRAN.

A GPU is the core of computer's display adapter and is controlled by the CPU. There are many cores working in parallel and they are called streaming processors (SPs). Several SPs constitute a streaming multi processor (SM). Each SM has its own-shared memory, and all the SMs in a GPU share its global constant, and texture memories. A typical program written in C using a GPU consists of CPU and GPU codes. The CPU codes control the process of the whole program, and the GPU codes do the parallel computing work. A function that executes on GPU is typically called a kernel. When a kernel is launched, the threads on a GPU organized by two levels are activated. The higher level is called the grid, and lower is called the block. One grid can consist of at most 65,535*65,535 blocks, and each block can consist of at most 512 threads. The grid is assigned to the GPU with blocks assigned to the SMs and the threads assigned to SPs.

Nevertheless, for parallel task with heavy computational burdens, GPUs usually can accelerate computing effectively. One example is the Tianhe-1A, currently the second fastest supercomputer in the world. It uses 7,168 Nvidia Tesla M2050 GPUs and 14,336 Intel Xeon CPUs. It would require more that 50,000 CPUs to deliver the same computing performance and the power consumption would increase from 4.04 megawatts to more than 12 megawatts.

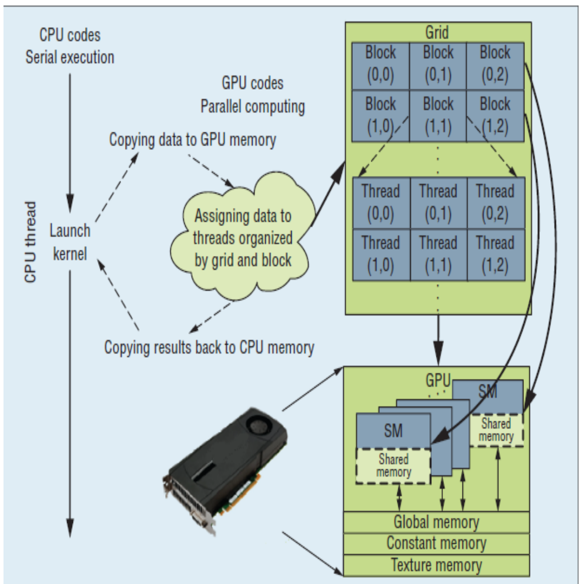

Figure 1. Graphics processing unit (GPU) parallel computing. With the streaming multiprocessors (SMs) working together, the GPU generates excellent performance in processing parallel tasks.

Figure 1 shows the basic principles of GPU parallel computing. With the SMs working together the DPU generates excellent performance in processing parallel tasks.

B. *GPU and HPC in Cloud Computing*

Cloud computing is described as highly scalable computing resources providing and external service via the internet on pay-as-you-go basis. It is internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand, as with the electricity grid. Cloud computing is a natural evolution of the widespread adoption of virtualization, service-oriented architecture, and utility computing. Economically, the main appeal of cloud computing is that customer only uses what the customer needs, and pays for usage. Resources are available to be accessed from the cloud at any time, from any location via internet. There is no need to worry about how things are being maintained behind the scenes-user simply purchases the IT service they need like other utilities. Because of this, Cloud computing has been called Utility computing of 'IT on Demand'.

There are mainly there types of cloud computing:

(i) ***Public Cloud:*** which is described as scalable, dynamic, virtualized resources available over internet from an off-site third party service provider, which divides up resources, and bills it customer on 'Utility' basis

(ii) ***Private Cloud:*** cloud refers as an internal cloud providing hosted services on private network. This type of cloud computing is generally used by large companies and allows their corporate network and data administrators to effectively become in-house 'service provider' catering to customers within the corporation.

(iii) ***Hybrid Cloud:*** is cloud environment combines resources from both internal and external providers. In this case a company cloud choose to use a public cloud service for general computing but it stores its business-critical data writhing its own internal cloud storage.

The GPU has already been used in cloud computing (see figure 2). Nvidia released the cloud-computing platform Reality Server based on its Tesla GPU servers. The platform can provide 3D graphics rendering web services to product designer, architects, and consumers around the world [10]. Amazon provides GPU resources for general purpose computing in its Elastic compute cloud.

The SE is public clouds with HPC specific hardware and software, e.g. large nodes memory, massive interconnection between nodes, special processors and HPC specific middleware, and applications. In 2010, HPC clouds were being explored by many HPC centers but used by only a few. Cloud computing appeals to some large HPC sites as a way to handle workloads with minimal communication dependencies and as a way to handle overload work without having to purchase them or hire HPC experts to operate them. The European Organization for Nuclear Research has announced to develop one of the world's biggest scientific cloud computing to distribute data, applications, and computing resources to scientists around the world. In the realm, Boeing and other companies have been remotely accessing the big supercomputer at Tata's Computational Research Laboratories in Pune for several years.

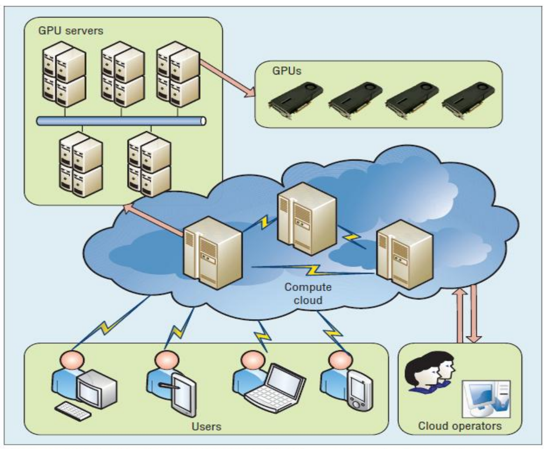

Figure 2. GPUs in cloud computing. To deliver the same performance using only CPUs would require much more resources.

HPC users are investigating the use of public clouds but there are few concerns. Many HPC applications require strong memory access at all levels, so cloud based on clusters without extra capabilities tend to perform poorly on these application. Many HPC applications are strategic applications to the organization and require a high level of security that currently public clouds cannot fully address. Many HPC applications have very large input and output data sets, making the data movement and storage slow and complex.

II. WIRELESS COMMUNICATION IN MISSILES

The secured and high-speed data wireless data networks are the order of the day in missile communication. Future systems may demand a data communication up to 10 Mbps or more. Communicating at high transmission rates over the harsh wireless environment, however, creates many difficult and challenging problems. The requirement of high RF bandwidth and implementation difficulties discourages the development of such system.

A. *Challenges:*

One of major critical aspect of missile development process is design of wireless communication system to suit the specific mission requirements. The following design constraints must be addressed and an optimum communication scheme should be selected during the design of communication.

The high velocity and acceleration with associated vibrations, roll and other mechanical disturbances is a major concern to the wireless data communication and the e equipment. The high velocity leads to high Doppler frequency, which create problems in tracking receivers.

The communication system should be efficient from the point of view of transmit power and signal bandwidth. The transmit power is mainly decided by the range of operation, signal bandwidth and signal to noise ratio of the proposed modulation method. Again, the power supply requirements largely depend upon the time of flight and transmit power. All the resource requirements are interlinked and are of conflicting nature.

The communication service should be reliable in terms of availability and quality. To ensure availability, hot redundant stand by system are necessary. Quality is assured by using channel-encoding schemes, which further increase the signal bandwidth.

Diversity is another efficient way to ensure communication availability. The space and frequency diversity methods are desirable.

During the flight of missile there are situation when aspect angle geometry between transmit antenna and receive antenna is worst which leads to communication loss. The aspect angle geometry is improved by increasing antenna beam-width and space diversity.

The design of communication system in conflicting requirements always demands space. The use of space diversity and hot standby redundancy is at the cost of extra space and weight. Long-range missiles need high transmit power, which leads to large heat generation that needs to be properly dissipated.

Spread Spectrum refers to a system originally developed for military applications, to provide secure communications by spreading the signal over a large frequency band. The idea behind spread spectrum is to uses greater bandwidth than the message bandwidth but the power remains the same. Moreover, this broadband signal looks like noise, for that frequency band, and therefore would be hard to tell if there is any signal at all. This provides security to the transmission since there would be no visible peak in the spectrum. Figure 3 gives more visual insight of the point.

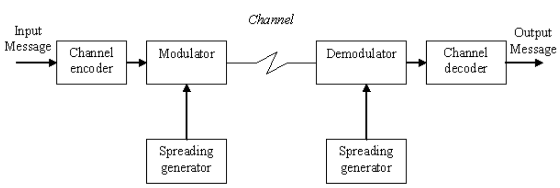

Fig. 3: Block diagram of spread spectrum communication

The spread spectrum air interface offer following advantages over conventional communication system.

- Low probability of detection (LPD)
- Low probability of intercept (LPI) > 15 dB
- Better Anti-jamming (A/J) margin > 15 dB
- Multi-path mitigation (Delay > ½ chip width)
- Multiple Access using Code Division Multiple Access (CDMA) and Selective availability

1. ***Direct-Sequence Spread Spectrum (DSSS)*:** With the DSSS technique, the PRN is applied directly to data entering the carrier modulator. The modulator, therefore, sees a much larger bit rate, which corresponds to the chip rate of the PRN sequence. Modulating an RF carrier with such a code sequence produces a direct-sequence-modulated spread spectrum with $((\sin x)/x)^2$ frequency spectrum, centered at the carrier frequency.

The main lobe of this spectrum (null to null) has a bandwidth twice the clock rate of the modulating code, and the side lobes have null-to-null bandwidths equal to the code's clock rate. Illustrated in Figure is the most common type of direct-sequence-modulated spread-spectrum signal. Direct-sequence spectra vary somewhat in spectral shape, depending on the actual carrier and data modulation used. Below is a binary phase shift keyed (BPSK) signal, which is the most common modulation type used in direct-sequence systems.

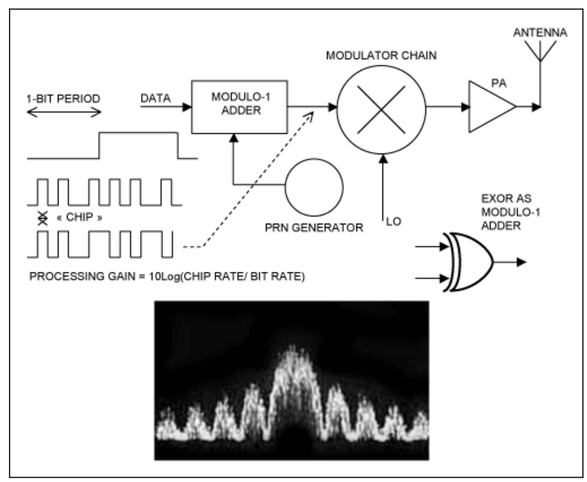

Fig 4: DSS

2. ***Frequency-Hopping Spread Spectrum (FHSS)*:**

The FHSS method does exactly what its name implies—it causes the carrier to hop from frequency to frequency over a wide band according to a sequence defined by the PRN. The speed at which the hops are executed depends on the data rate of the original information. One can, however, distinguish between fast frequency hopping (FFHSS) and low frequency hopping (LFHSS). The latter method, the most common, allows several consecutive data bits to modulate the same frequency. FFHSS is characterized by several hops within each data bit.

The transmitted spectrum of a frequency-hopping signal is quite different from that of a direct-sequence system. Instead of a $((\sin x)/x)^2$-shaped envelope, the frequency hopper's output is flat over the band of frequencies used. The bandwidth of a frequency-hopping signal is simply N times the number of frequency slots available, where N is the bandwidth of each hop channel.

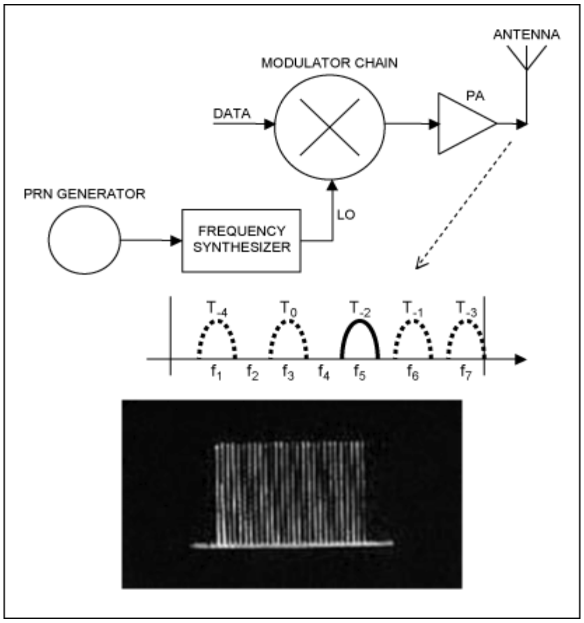

Fig4: FHSS

3. Missile Application:

Point-to-Point Communication Links: The point-to-point RF links are widely used in most civilian and military communication because of portability and simplicity. The general form of point-to-point link is given in fig

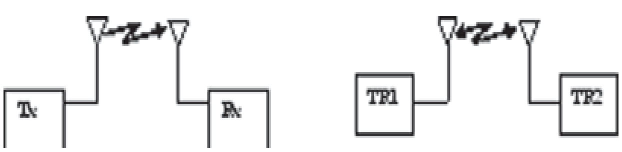

Fig5: One way Link **Two-way Link**

The one-way communication links are often used for providing target or command update in missiles. Mainly data is transmitted from launching platform to the missile. These links may be surface-to-air, ship-to-air or air-too-air communication system. Transmitter is mounted on launcher and receiver is mounted on missile. They are the simplest form but widely used links.

The two ways communication link consist of up and down links. The up link is used for target or command update and down link is used for multiple purposes. The down link may give navigation data back to ground which can processed at faster speed and results can be given to missile via up-link. The result can be mathematical data or can be in the form of commands. The downlink can be used to give missile navigation data back, which can be used for slaving the tracking system. The downlink can also used for video transmission purpose in which missile borne Camera video or IR Seeker video can be transmitted. The launching platform and missiles both use transreceiver on them. The up and down link can be either half-duplex or full duplex.

Non line of Sight Communication Links: The point-to-point links are line of sight links. The link works if a proper line of sight between transmitter and receiver exists. However, there are situations when line of sight does not exist. Under such circumstances, the intermediate nodes (repeaters(R)) are used to establish communication between nodes without line of sight. The repeaters can stationary or mobile elements and the individual links are always line of light.

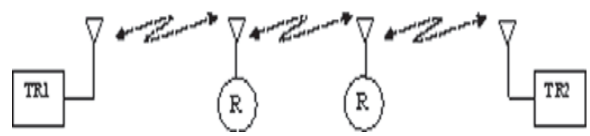

Fig6: Non line of sight communication

Ad-hoc Networks:

A typical broadcast network is shown in Fig. Such a network is often required when multiple missiles are launched from a single launching platform. The network management is done by launching pad transmitter node, which acts as a master. Other nodes are passive receivers on missiles. They operate in slave mode. The communication is done in highly time-synchronized manner under the tight supervision and control of master node using command response protocol. The network works in broadcast mode of communication.

Both way communications is possible in this arrangement by using a trans-receivers in each node. A proper handshaking protocol is required for handling two-way communications. Generally, the network use half-duplex communication in time division duplex mode. The time slots for each node should be properly identified and controlled by communication protocol.

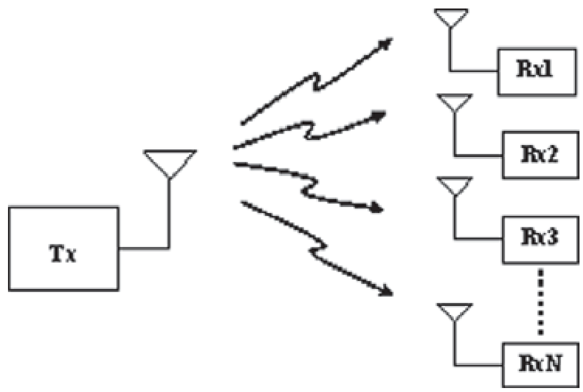

Fig. 7: Broadcast network link

The following example is another form of ad-hoc network. Mostly for air-to-air attack, the fighter aircrafts move in formation with some sort of ad-hoc communication network within them.

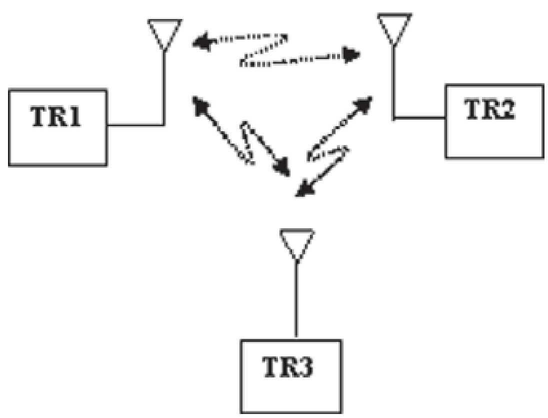

Fig. 8: Ad-hoc network.

When a missile is launched, it also becomes a part an ad-hoc network. This arrangement helps if a parent aircraft fails to communicate with missile. The parent aircraft gives a hands-off to the other aircraft, which subsequently communicates with missile.

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