



Company Background

Digital Resources, Inc. (DRI) was formed in 1981 by a former product development manager for the North American Philips Communications System Division, a wholly owned subsidiary of Philips NV. DRI is located in the northernmost area of New Jersey, 35 miles northwest of New York city. One DRI location is used for fabrication, system integration, factory acceptance testing, training, and hardware and network technical support. Another location is used for software development and administrative offices.

DRI's founder participated in the hardware and system design of the Philips store-and-forward message switching systems in both the Netherlands and the U.S.A. These communication systems were installed throughout the world in AFTN, Telex, weather message distribution systems, international CCITT F.31 message switching systems, and industrial/commercial microprocessor-based message preparation and delivery systems.

DRI's initial product development efforts supported the Philips installed customer base by providing state-of-the-art extensions, such as main-memory and advanced peripheral subsystems that greatly increased the capacity, reliability, maintainability, and system life cycle of the original Philips systems. The first DRI product was installed in the FAA Weather Message Switching System (WMSC) in Kansas City. This product replaced the original CPU memory with the first error-checking-and-correction (ECC) memory, combined with what is now termed 'flash-memory', that was used in any store-and-forward message system then in operation. This same product was installed in message switching systems throughout the world.

The second product on the same WMSC system was a multiple microprocessor-based front-end-processor (FEP) that collected and distributed weather information throughout the USA. The combination of these 2 products extended the life cycle of the FAA WMSC system by at least 12 years. In fact, these same DRI products have extended the life cycle of the current FAA AFTN system (NADIN-IA), by 8 years to date. A very recent FAA NADIN-IA upgrade from DRI will extend its life cycle at least another 5 years (or beyond, if the ATN is further delayed).

Although the first main-memory product was entirely a hardware design task, all subsequent products, until recently, have been a combination of microprocessor-based hardware and software design efforts. Recent product development efforts have concentrated exclusively on applying commodity-level personal computers in a distributed networked architecture to implement communications systems.

The above products were installed and supported in a variety of communications systems throughout the world, such as : MCI, RCA Global, Western Union International, Unitel Canada, AT&T Canada, Canadian National, Venezuela Civil Aviation Agency, Sweden Civil Aviation Agency, Irish Aviation Authority, and USA Federal Aviation Administration. DRI continues to provide support to the FAA AFTN system on an annual contract basis.

Design Philosophy

During the mid 1990's three emerging trends had a significant impact on DRI's product development plans during the design of the Multi-protocol Message System (MMS). As a result of these increasingly negative and significant trends, DRI designed the MMS to minimize or completely nullify the impact of these factors described below.

Vendor Dependence

The first trend was highlighted by the highly publicized FAA problems coping with critical equipment failures on an aging system base that was increasingly difficult and expensive to maintain. This difficulty was a direct consequence of employing systems based on highly proprietary vendor-specific system components. Even though many of these same system components were touted as 'commercial-off-the-shelf'(COTS), it was a moot point, since they could only be provided by a single source. Once that component was cancelled, or the vendor was acquired or dissolved, the entire system became vulnerable. Not only could the system no longer be upgraded to meet ever-increasing demand, in many cases the system could not even be maintained.

Another well publicized case was the takeover of both Digital Equipment Corporation and Tandem Corporation by the PC manufacturer Compaq Corporation. Both of these 2 large companies supplied many of the fault-tolerant systems employed in the AFTN applications throughout the world. As in the case of any acquiring company, unprofitable or niche market product lines are typically terminated shortly after the takeover. Once the product line is terminated, it is only a short time before all ongoing maintenance and spare parts support is declared to be at an 'end-of-life-cycle' phase, whereby all support is dropped within 6 months. This takeover by Compaq highlighted the critical importance of vendor independence wherever possible.

System Unreliability

The second emerging trend was that even the very largest and most expensive AFTN systems are unreliable and prone to message loss and excessive message delivery delays. In comparison to the now commonplace wide-area-networks (WAN), the point-to-point AFTN systems fare poorly. Without exception this is the case, even though AFTN systems typically handle only a fraction of the message traffic on most WANs. This fact is not yet widely recognized, since many AFTN messages are not critical, and there is no controlled method to measure message delay or message loss. Recent controlled operational tests however, have documented just how unreliable many AFTN systems are.

The primary cause of this poor AFTN performance is the inadequate error detection of the message text, combined with lack of error-correcting protocols. Unlike typical AFTN systems, the far more reliable wide-area-networks employ *cyclic-redundancy-check* (CRC) bytes to detect errors. This much more rigorous error checking method is also employed on an end-to-end basis within the MMS AFTN system. In a typical AFTN system, even when an error detected is within the text of a message, it requires manual intervention by at least 2 people to recover the problem message. Often, this recovery effort is unsuccessful, or results in a delay which makes the recovered message irrelevant.

Additionally, at the system level, the concentration of the switching and routing function into a single or dual (standby) system adds to the unreliability. Since the standby system

is only used in the event of failure, any latent hardware fault goes undetected until the very moment the standby system is forced into use by a failure of the on-line system. The inevitable result is a total system failure.

In almost all cases, these dual systems depended upon a highly proprietary circuit interface unit that allows only one of the 2 available systems to control the communication lines. Not only does this design introduce a 'single-point-of-failure', but the resulting vulnerability often requires round-the-clock maintenance and operational staff support that drives up the cost of system operation. Even in the case of fault-tolerant systems, the single common interface point to the communication lines makes the fault tolerant systems almost as vulnerable to total failure as the dual standby system approach.

Some system vendors attempted to improve the reliability of AFTN systems by implementing expensive workstations as the message switching functional element. These workstations typically implemented Error Checking and Correction (ECC) main memory and RAID level 5 hard disk subsystems. Although this definitely improved the reliability of the computer itself, it did nothing to eliminate the communication line interface as a single point of failure. Today, many PCs are available with both ECC and RAID level 5 hard disk subsystems, at a fraction of the cost of the workstations. However, in a properly designed distributed architecture, these more complex PCs are not required, since the distributed architecture itself achieves the maximum possible reliability.

Another common cause of AFTN system failures is the fact that many AFTN systems are operating at (or beyond) their maximum capacity. Thus, almost any unique event, however trivial, causes a total system failure. Since there are typically no meaningful real-time statistics available at the time of failure, the cause is often mistakenly attributed to the 'unique event'. The actual cause however, is that any system operating at its maximum capacity is vulnerable to almost any trivial event, such as a high queue load due to a line out of service. This is often why, when one AFTN system fails, it also takes down the connected AFTN system of the adjoining state when the failed system is restarted.

In those cases where this ultimate cause is properly recognized, there is frequently no recourse for the organization operating the AFTN system. Even in the rare case where the original vendor is still in the AFTN business, the system architecture precludes any significant expansion beyond the initial installation. There are also cases where the design permits some degree of expansion, but a vendor specific proprietary component required for the expansion is no longer available.

Some vendors attempted to deal with this AFTN reliability issue by introducing ICAO CIDIN-based interfaces to their AFTN systems. This partial step only improved the reliability between countries/states, but did nothing for the far more numerous communications lines within states. Other vendors provided a "gateway" to an external WAN, but this still left all internal AFTN users as vulnerable as before, since the internal AFTN communication lines were still point-to-point, with minimal error checking, no error correction, and with no automatic alternate path to the end-user.

System Inflexibility

Even in the very rare cases where an AFTN system was more than simply an obsolete point-to-point network, the system was incapable of adapting to the newer low cost network technologies. As new telecommunication service providers entered the market, the existing typical AFTN system was locked into whatever single line protocol was

Implemented at system installation. Typically, this network technology was X.25. Thus, as other non-AFTN networks were able to take advantage of newer lower cost technologies, such as TCP/IP, Frame Relay, ISDN, DSL, dial-up access, etc. the AFTN system was forever locked into only X.25 or, even worse, point-to-point lines. Any modern store-and-forward system should be able to combine any mix of these networking technologies into a single AFTN network. Since market conditions frequently change, the system must be capable of easy reconfiguration to the optimum hybrid network, based on changing cost/benefit trade-offs.

In response to these 3 serious vulnerabilities, of vendor dependence, poor reliability, and an inflexible architecture, DRI developed the Multi-protocol Message System (**MMS**). The MMS system resolves all of the above described reliability problems at a cost significantly below the price of the traditional point-to-point AFTN systems. The MMS system today offers all of the advantages of the future ATN, at a lower operating cost than will be available when ATN is finally implemented.

As a result, the end-to-end error checking, based on the same CRC method used in wide-area-networks, combined with the distributed architecture, makes the MMS system the most reliable AFTN system in operation today. A detailed description of this store-and-forward message switching system is available in the MMS Product Specification document.

Recent DRI Projects

Irish Aviation Authority Air-Ground Communication System

The Air Ground communication system, installed by DRI in early 1998, is a totally distributed system connected on a dual 10BaseT local-area-network (LAN) that provides for communication between aircraft on the north Atlantic and air traffic controllers in Scotland. The north Atlantic is the most heavily traveled international route and the new system totally eliminated the increasing message delays, even during the peak hours of the peak period from June through September.

Since the system employs 16 PCs to cover the different radio frequencies, and the PCs are interchangeable, there is no longer any possibility of system failure. The dual-LAN and multiple gateways eliminate any 'single-point-of-failure'. Corrective maintenance takes only 10 minutes and consists of simply replacing the entire PC. Because of the large quantity of on-line low-cost redundant positions available, any corrective maintenance can be deferred until day-shift staff is available.

All user interface functionality is totally automated, even to the point where position reports are geographically addressed, based on the current and estimated position of the flight. Quality control is greatly enhanced since all position reports are validated based on 'reasonableness checking' parameters of flight level, speed, time, latitude, longitude, and aircraft type. For example, the 'reasonableness checking' parameters for a Concorde flight position report are different than those for an ordinary commercial aircraft.

FAA NADINIA System Enhancement

DRI recently replaced all of the advanced peripheral systems, previously developed by DRI, with newer higher capacity systems that are based on industry standard SCSI interface. These new subsystems are non-proprietary peripherals and can extend the life

cycle of the NADIN-IA system by at least 5 years. DRI also provides on-going technical support on an annual contract basis for this FAA AFTN system.

Irish Aviation Authority AFTN Communication System

The AFTN MMS system, developed by DRI, was the first system implemented on the IAA national wide-area-network. As part of this project, DRI was tasked with selecting the routers to be used throughout the entire national network. The DRI AFTN system is now integrated with radar and other navigational aids on this common national WAN. Because the MMS system extends the redundancy and error correction beyond the boundary of the WAN, the AFTN system is more reliable than the other systems operating on the same WAN.

The routing and switching functions are distributed across 5 PCs, any one of which is capable of handling the entire traffic load. Since there is no fixed relationship between a switch PC port and the distant concentrator port, any PC can and does address any other PC in the entire network. This feature makes a system crash impossible. The low cost PCs also make feasible the redundancy at all points throughout the network. This same low cost PC based remote intelligence makes available the error correcting Ack/Nak protocol at even the most remote AFTN terminal in the system. This MMS Ack/Nak protocol operates at the level above the Ack/Nak protocol built into the protocol of routers transporting the AFTN message at the lowest level.

Eventually, when the ATN is finally deployed, it can be easily integrated with the current MMS AFTN system, by simply making entries in the routing tables of the routers. The routers will handle the protocol translation (if any), and the MMS system will handle the ICAO address translation. DRI also offers, as an option, X.400 message capability and the AMHS gateway B functionality. Thus, if necessary, the existing MMS system can be incrementally converted into a full AMHS system required by the ATN specification, without any change to the existing hardware components.

In addition to the main switching system and concentrators, a totally independent 'contingency switch' is operating in parallel with the main switch. This 'contingency switch' is located 18 miles away from the main switch. Its sole purpose is to take over the network in the event of a **physical** catastrophic event, such as fire, flood, or explosion, at the main switching system. Since this unmanned 'contingency switch' operates on the same WAN as the main switching system, it receives the same input traffic, directly from the concentrators, at the same time as the main switching system. The 'contingency switch' and the main switching center can both be controlled from a remote location.

This IAA AFTN system provides almost unlimited scalability. Even no expansion however, the current IAA system could easily handle the most heavily loaded AFTN systems currently in operation, such as the FAA NADIN-IA system in Atlanta and Salt Lake City. Of even greater importance than scalability is the fact that this MMS system provides the IAA with total vendor independence and guaranteed long-term low cost maintainability. The IAA MMS system is the most advanced AFTN system now in operation.