RTP3000 TAS N$^+$

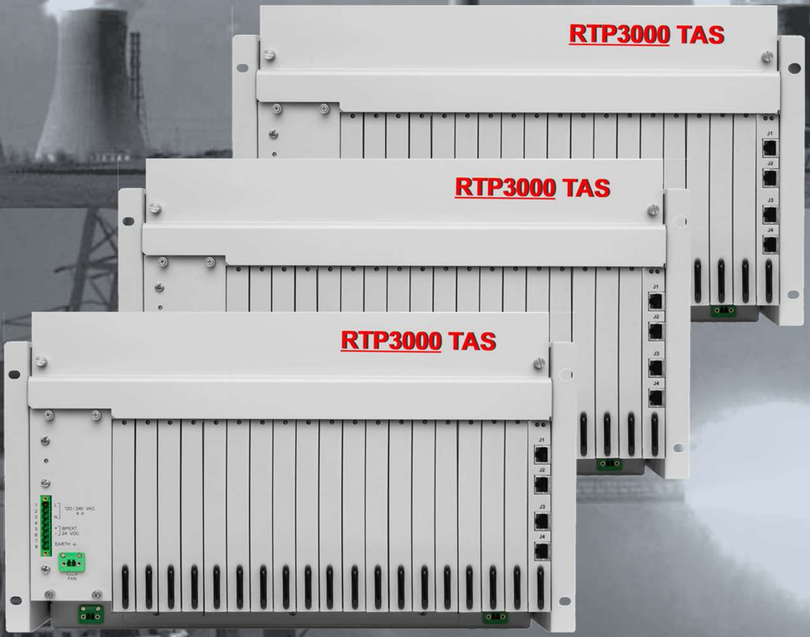
Technologically Advanced System

IEC61508-2010
SIL 1-3
IEC61131-6

EDSA-300
Level 2

Quad Modular Redundant

- Cost Less
- Runs Faster
- Never Stops

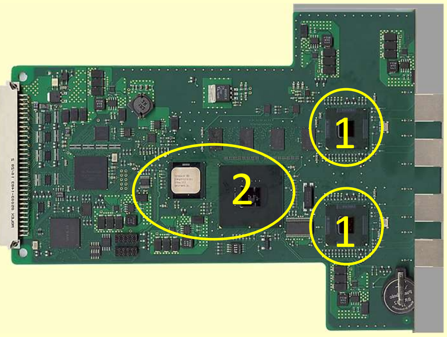


Triple Modular Redundant

10 Year Warranty

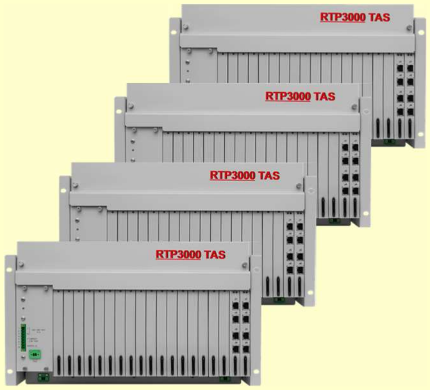
RTP3000 Family,
Designed
By Engineers
For Engineers

Runs Faster



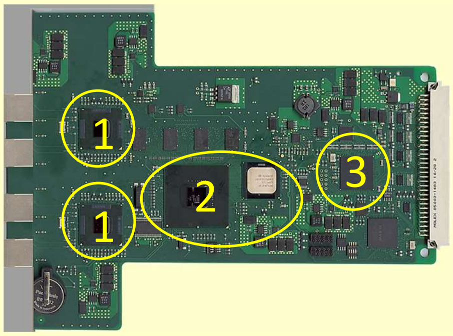
Node Processors Tasks:

- Logic solving (N-Times)
- Engineering unit conversion
- Input validation and voting
- Alarm communications
- Data Archiving communications
- HMI and other communications
- Peer to peer communications
- Communications validation



Processor:

Mobile Intel® Atom™ 1.33GHz Processor
System Controller Hub with integrated floating-point unit
512Mbyte 64bit wide SDRAM



Chassis Processor Tasks:

- Chassis I/O scanning
- 1 msec Digital SOE
- 1 msec Analog SOE
- Results validation and voting
- Backplane validation
- I/O integrity checks
- Field device checking
- Field wire checking

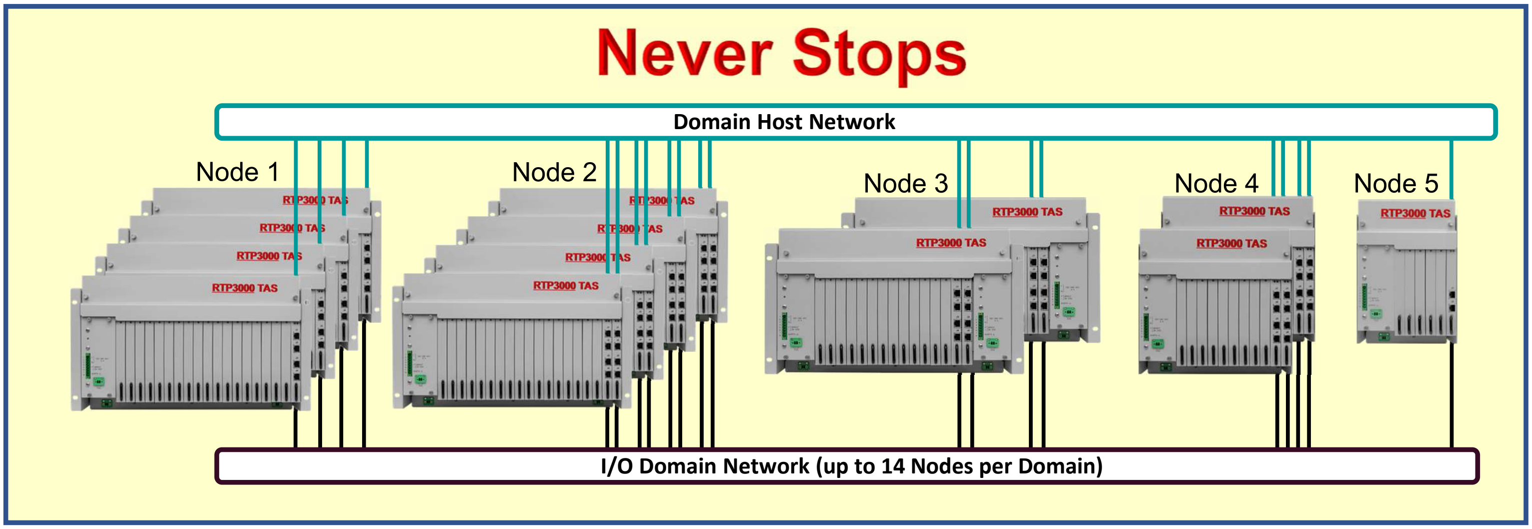
RTP has fundamentally changed the way Control and Safety systems work:

Since the advent of the technology, all PLCs, SIS's and DCS Systems have worked the same way. A processor or set of processors scans the inputs, then solves logic, then sets the outputs, then does communications, and runs diagnostics. Then it starts over again. This means that the scan time (and therefore the reaction time) is dependent on the amount of I/O and the complexity of the logic. This also means that the diagnostics done by this processor or set of processors directly affects performance. Designers of traditional systems must make trade-off decisions between allowable scan times and the number of diagnostics that will be done. A combination of these issues explains why the industry has been conditioned to expect SIS scan times of 200 milliseconds and to believe that 1 to 2 second updates on process variables is not only acceptable, but preferable.

Unique Architecture:

One of RTP's core competencies is the ability to apply technology in unique ways to solve control problems. This ability led to the creation of the architecture used in the RTP3000 Critical Control and Safety System. The earlier generations of the RTP3000 and the TAS systems started with an architecture consisting of Node and Chassis processors which divides the processing requirements up. The Node Processor tasks are to solve logic, vote inputs and results, schedule diagnostics and communicate to the Host network. The Chassis Processor tasks are to scan I/O, store SOE and Alarm points, and perform diagnostics as directed.

The N^+ architecture pictured above, combines the Node and Chassis Processors onto one board. The N+ system utilizes multiple processors (Node Processors) and divides the control task (as seen above) between them, offering the end user unparalleled speed. This architecture also provides for the addition of processing power as the application grows. No matter how much I/O is added to the system, the scan time will not be affected since additional node processors will be added each time a new I/O chassis is configured. In a QMR configuration 4 Node Processors work in parallel to perform all tasks required in less than 1 msec. As more nodes are added to a domain and if they are all Quad nodes, the number of **processors** working in parallel grows to **56**. As seen above each Node Processor consists of three unique microprocessors (CPUs). CPU (1) is dedicated to communications tasks. When a message is being received or transmitted to either network, it performs error checking and if all checks ok, it DMAs (direct memory access) the message into memory. CPU (2) is a very fast general-purpose microprocessor and when coupled with a floating-point hardware assist is capable of very fast floating point math. An advanced technique, hyper-threading, has also been used to add even greater performance. CPU (3) is dedicated to scanning all of the I/O in its chassis, time stamping of SOE and Alarms to 1 msec. A unique capability of this hardware is that it can be configured as a safety system (**ESD or Fire & Gas**), a control system (**DCS or PLC**,), or a rotating machinery control (**ITCC**) system simply by changing the embedded operating system.



Configurable Redundancy:

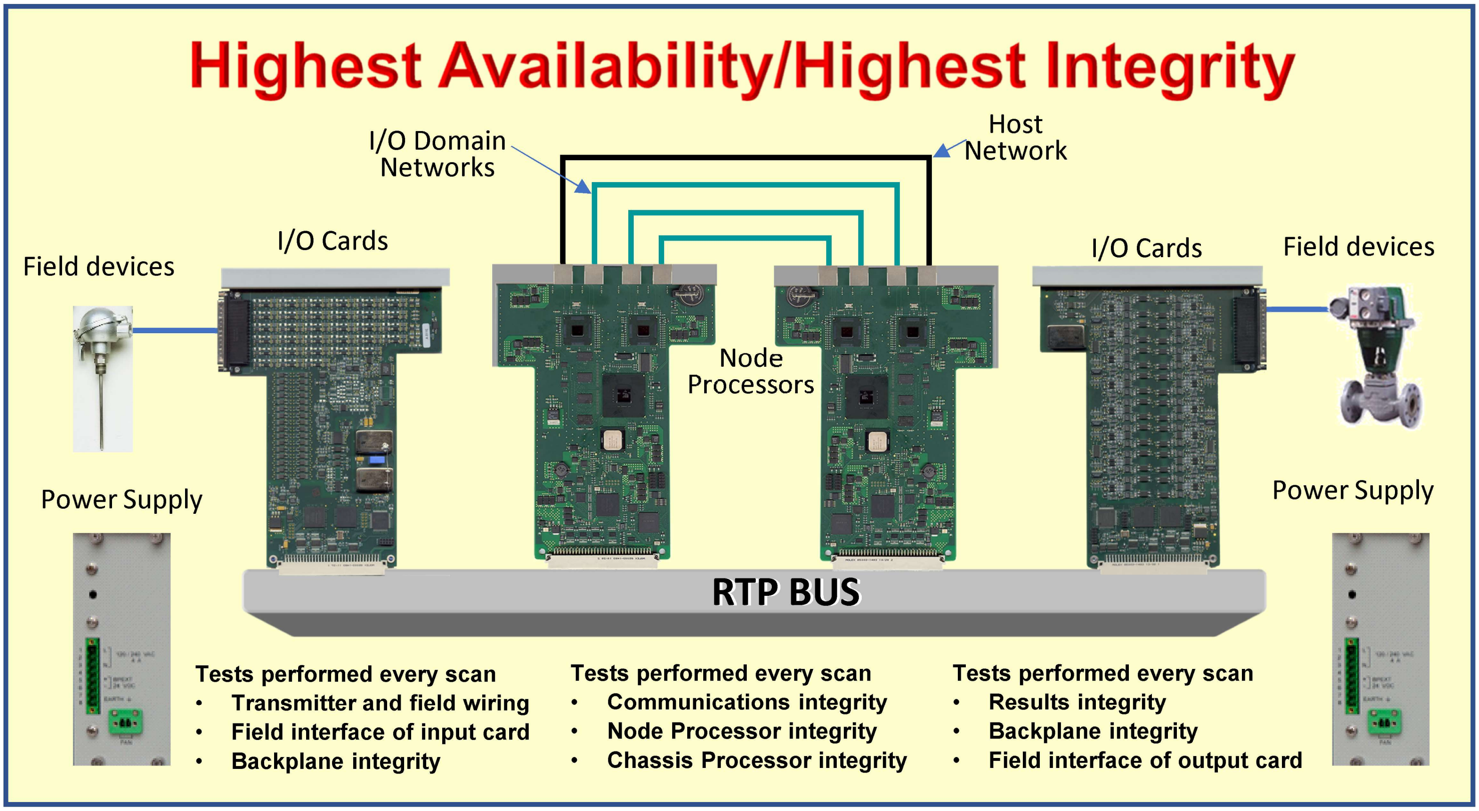
Traditional architectures impose limits on the user's ability to configure the system to meet their needs. Conventional TMR systems basically consist of three PLCs connected in parallel. In these TMR systems, the three processors must reside in the same chassis to utilize backplane speeds for synchronization and diagnostics. Also, selecting a triplicated I/O module means that all points on that module will need to be triplicated. If one PLC goes off-line for any reason, all I/O associated with that PLC is also lost resulting in a dramatic reduction in integrity.

Now, RTP has changed all that:

The RTP3000 and the TAS systems started with an entirely different architecture. First, the 4 Node Processors can be mounted in one chassis or in separate chassis preventing the possibility of a single physical event taking out the safety system. Redundant inputs can be configured to be on one card, on different cards in the same chassis, or on different cards in different chassis. With this system all failures are isolated to that particular card and can not propagate to other parts of the system. This includes power supplies which are constantly tested to make sure they will perform properly if needed. This is the best possible form of redundancy when all processors, I/O cards and power supplies are configurable independently.

Now with the introduction of the N^+ architecture pictured above, RTP has extended the concept of a distributed architecture. The N^+ system combines the chassis processor and node processor into a single Node Processor. The concept of this architecture is that every time you add a chassis you add another node processor and distribute the application to each chassis rather than a central node as its predecessor systems did. All systems start with at least one node processor. So, N equals 1 for the first chassis and for every additional chassis there is a new node processor and the number (N) increases. If we look at the drawing above, node 1 is in effect a quad architecture with four Chassis, four Power Supplies, and four Node Processors. Node 2 adds four additional Node Processors in hot standby mode. So, if any of the primary four Node Processors shuts down for any reason, one of the standby processors will join the remaining Node Processors to once again become a quad processor system. Nodes 1 & 2 above can also be configured as a single, dual, or triple system. Nodes inside a Domain can be single, dual, triple or quad redundant. Variables are passed between Nodes in a Domain using its private Domain I/O Network and between Nodes in other domains using Peer to Peer. Nodes 3 & 4 are different variations of a quad system. There is no practical limit to the number of Domains in a system. The result is that as more logic and I/O are added to the system, more compute power is also added and the scan does not have to increase.

The redundant Node Processors communicate with each other over 1Gbit SIL-3 Ethernet network rather than over the backplane. Over these networks, scans are synchronized and extensive diagnostics are done by each Node Processor on every other Node Processor. I/O is shared to other nodes in a domain using the domains I/O network, a SIL-3 rated Ethernet network. In a configuration of redundant I/O, every Node Processor receives all I/O information from every other Node Processor. Each Node Processor does an independent 2oo3 vote on all inputs and begins its scan with the result of its own vote. On the output side, you can configure the system for redundant or triplicated outputs. This is possible for a number of reasons. First, outputs are voted in the Node Processor before the command is transmitted to the output module. Then, the command is sent to the output module twice and the two commands are compared by the output module. Finally, on the output module, two FET's must energize in order for the output to be energized. Therefore, each output is the result of several votes, providing maximum integrity.



Highest Availability/Highest Integrity

Tests performed every scan

- Transmitter and field wiring
- Field interface of input card
- Backplane integrity

Tests performed every scan

- Communications integrity
- Node Processor integrity
- Chassis Processor integrity

Tests performed every scan

- Results integrity
- Backplane integrity
- Field interface of output card

Availability and Integrity:

Availability is about the system being available to take action when necessary. Basically, that means redundancy. Integrity is about the control system making good decisions when it is called on. That is about diagnostics and about internal tests of system capability. A trade-off between these functions is what many systems end up doing.

The N^+ system provides both availability and integrity, from the input device to the output device, redundancy is applied, diagnostics are done, and internal tests are conducted to insure the highest level of availability and integrity.

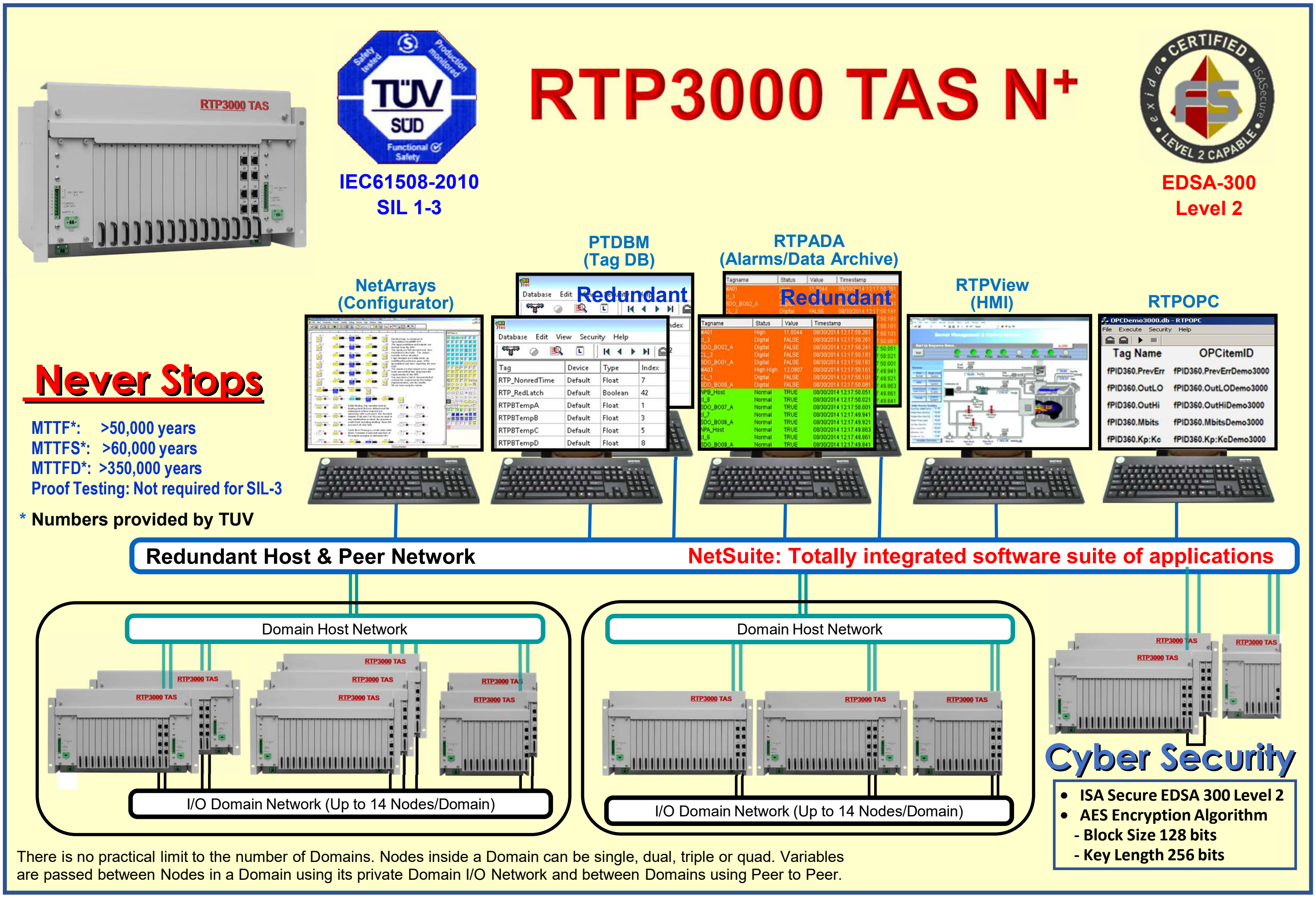
Availability:

Traditional architectures impose limits on the user's ability to configure the system to meet their needs. Conventional TMR systems basically consist of three PLCs connected in parallel. In these TMR systems, the three processors must reside in the same chassis to utilize backplane speeds for synchronization and diagnostics. Also, selecting a triplicated I/O module means that all points on that module will need to be triplicated. If one PLC goes off-line for any reason, all I/O associated with that PLC is also lost resulting in a redundant system and a dramatic reduction in integrity.

Configurable Redundancy: With the N+ system you chose the level of redundancy that is required. Single, or dual, processors can be in one chassis or separated into different chassis, the choice is yours. The same is true of your I/O selection. Again, either single, dual or triple redundant options are available. In the case of redundant points, they can be located on separate cards which accommodates easy replacement in the rare times that they may need replacement.

Integrity:

The N^+ architecture pictured above, combines the Node and Chassis Processors onto one board. This distributed architecture achieves a **1 Msec scan time** and also has an **MTTFS of 60,000** years. As can be seen above, every element of the system from transmitters to valves are continually test. Line supervision is used on field instruments to detect opens or shorted lines. All data to and from the Node processors is protected with multiple CRCs. Each processor solves logic 3 times per scan with the data located in 3 different locations in memory and than a vote is made. If a difference is found that data set is corrected so that all 3 are once again in sync. The next 2 pages describe in more detail the level of diagnostics of the system.



RTP3000 TAS N^+

IEC61508-2010
SIL 1-3

EDSA-300
Level 2

Never Stops

MTTF*: >50,000 years
MTTFS*: >60,000 years
MTTFD*: >350,000 years
Proof Testing: Not required for SIL-3

* Numbers provided by TUV

Database Edit View Security Help

Tag	Device	Type	Index
RTP_NonredTime	Default	Float	7
RTP_RedLatch	Default	Boolean	42
RTPBTempA	Default	Float	1
RTPBTempB	Default	Float	3
RTPBTempC	Default	Float	5
RTPBTempD	Default	Float	8

OPCDemo3000.db - RTPOPC
File Execute Security Help

Tag Name	OPCitemID
fPID360.PrevErr	fPID360.PrevErrDemo3000
fPID360.OutLO	fPID360.OutLODemo3000
fPID360.OutHi	fPID360.OutHiDemo3000
fPID360.Mbits	fPID360.MbitsDemo3000
fPID360.Kp:Kc	fPID360.Kp:KcDemo3000

Redundant Host & Peer Network

NetSuite: Totally integrated software suite of applications

Domain Host Network
RTP3000 TAS
I/O Domain Network (Up to 14 Nodes/Domain)
Domain Host Network
RTP3000 TAS
I/O Domain Network (Up to 14 Nodes/Domain)
RTP3000 TAS

Cyber Security

- ISA Secure EDSA 300 Level 2
- AES Encryption Algorithm
  - Block Size 128 bits
  - Key Length 256 bits

There is no practical limit to the number of Domains. Nodes inside a Domain can be single, dual, triple or quad. Variables are passed between Nodes in a Domain using its private Domain I/O Network and between Domains using Peer to Peer.

No single point of failure: Failure of any single component will not affect the correct operation of the N^+ system.

Highest integrity: With its QMR architecture and high diagnostic coverage, the N^+ system achieves availability in excess of 99.9999% (6NINES).

Highest availability: An N^+ system has an MTTFS of greater than 60,000 years using the failure rates defined in the IEC 61508 Standard.

Highest performance: The N^+ domain provides processing power capable of solving in excess of hundreds of PID control loops every 1 Msec including scanning of I/O, logic solving, alarm handling, as well as peer-to-peer and other communication functions.

Transparent quad configuration: The N^+ is four physically separated, parallel control systems integrated into one control node. Three out of four (3oo4D) voting provides high integrity, error-free, uninterrupted process operation.

Design flexibility: The ability to be configured according to the level of availability and system cost required. Simplex, dual, triple, or quad redundant I/O modules allow you to choose between different levels of coverage ranging from simplex to QMR.

Comprehensive diagnostics: The ability to provide complete on-line diagnostic coverage. The N^+ system provides this capability without additional hardware or special programming. Both single and redundant power supplies are monitored and proof tested on a continuous basis to insure proper operation of the system.

Online repair: The N^+ is designed for continuous operation, providing on-line replacement of modules without system or process interruption.

Lowest MTTR: Online replacement and extensive built-in diagnostics which automatically pinpoint faults to field replaceable modules allows return to be accomplished quickly without process interruption.

RTP Fault Tolerant Scalable Distributed Safety System

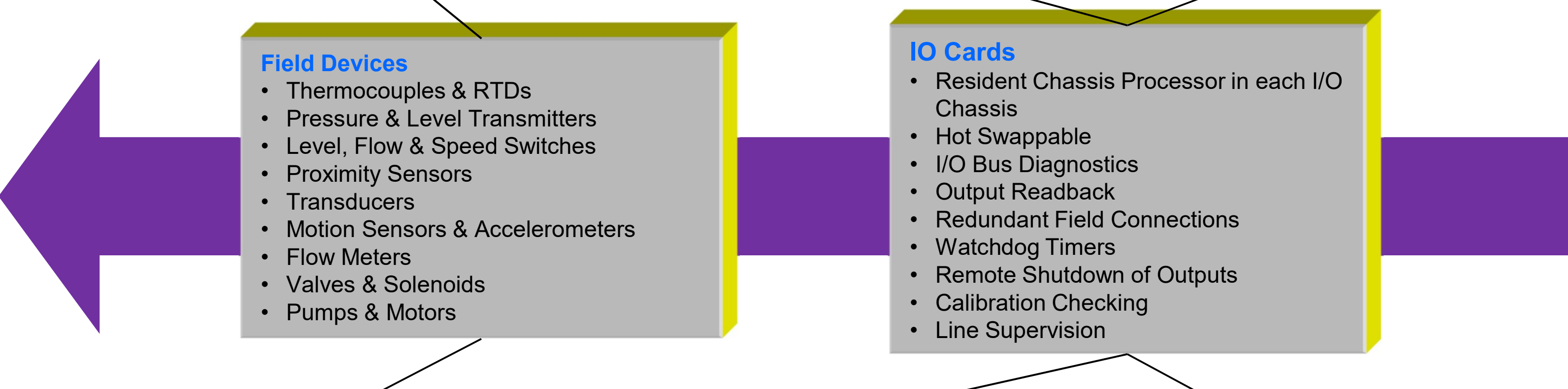
Protection for your process with high-integrity and high-availability

High Availability

Sensor Redundancy :
For mission-critical applications, multiple redundant sensors can be employed ensuring the highest levels of sensor availability. Redundant sensors can be connected to one or more I/O cards, to ensure a valid process variable input in the event of a sensor failure.

I/O Card Redundancy:
A single process variable input can be connected to one, two or three input cards residing in either common or redundant I/O chassis. This ensures a valid input is available upon the loss of an I/O channel, I/O card or I/O chassis. I/O redundancy is also available on a channel, card or chassis basis regardless of controller redundancy.

I/O Chassis:
Each I/O chassis provides mounting space for 5 to 18 I/O cards depending on the chassis selected, and contains its own resident I/O Chassis Processor. The Chassis Processor performs all I/O scanning functions, floating-point EU conversions, voltage to temperature conversions, input and output validation and I/O card diagnostics, and sends the collected and converted data to the 3000 Node Processors.



Field Devices
- Thermocouples & RTDs
- Pressure & Level Transmitters
- Level, Flow & Speed Switches
- Proximity Sensors
- Transducers
- Motion Sensors & Accelerometers
- Flow Meters
- Valves & Solenoids
- Pumps & Motors

IO Cards
- Resident Chassis Processor in each I/O Chassis
- Hot Swappable
- I/O Bus Diagnostics
- Output Readback
- Redundant Field Connections
- Watchdog Timers
- Remote Shutdown of Outputs
- Calibration Checking
- Line Supervision

High Integrity

Signal Validation:
RTP's Signal Validation routines produce one logical input from up to four redundant inputs (three physical inputs plus one optional logical input). Input signal validation supports either redundant sensors from the field or redundant inputs, on a channel or on a card basis. Various algorithms are available for determining the validated input.

I/O Card Diagnostics:
- Advanced diagnostic capabilities on RTP I/O cards ensure that a measurement or a control signal's integrity is not affected by card failure:
- Thermocouple: configurable Open Thermocouple Detection (OTD) detects a failed thermocouple or open line.
- Line Supervision: imposing a very low current and measuring the continuity of the line validates the line between the RTP I/O card and the sensor or field device.
- Analog Input Cards: functionality check of all active components.
- Output Cards: readback ensures the commanded output is the actual value sent to the field device.
- Output Integrity: Even if outputs are activated rarely, control must function properly. When the demand comes to turn off an output but a failure occurred much earlier, the chance for effective diagnostics may be gone. On an RTP system, output circuits are continuously tested.

I/O Data Transfer Diagnostics:
- I/O data is transferred to the I/O Chassis Processor over the RTP Bus. To maintain high integrity on the RTP Bus, the following techniques are implemented:
- Data faults are diagnosed by sending data first, then sending the same data inverted. The receiver (Chassis Processor or I/O card) bit compares the inverted data. Any discrepancy initiates a shutdown of the relevant unit (a redundant unit can continue operating).
- Faults in the command lines are detected by command/response messages to ensure that the correct devices are communicating.
- Faults in the address lines are detected by comparing card IDs in the command line. If these do not match, a shutdown of the unit is initiated.

Fault Tolerant Process Control:

Fault tolerant process control begins with the creation of a project program on a windows®-OS PC running NetArrays, RTP's user application development environment. The project program contains the configuration of all the process control logic and, in addition, the diagnostic logic (such as error status response and input validation). Once the project program is completed, it is compiled for downloading to the Node Processors.

Download Mode:

The compilation process produces the program image, which is verified for integrity and completeness. Any PC-related problem in the compilation process will abort the operation to prevent the download of a faulty program image.

The program image is then downloaded to each of the redundant Node Processors using our TCP/IP communications protocol, which includes multiple CRCs within the message. When the Node Processors receive the program image they perform CRC checks to validate the image before taking any action.

Each Node Processors sends its copy of the I/O configuration to the Chassis Processors via the I/O network. In single processor configurations, the Node Processor sends two copies of its I/O configuration to the Chassis Processors. The Chassis Processors then perform CRC checks and comparisons before the system enters Run Mode.

Run Mode:

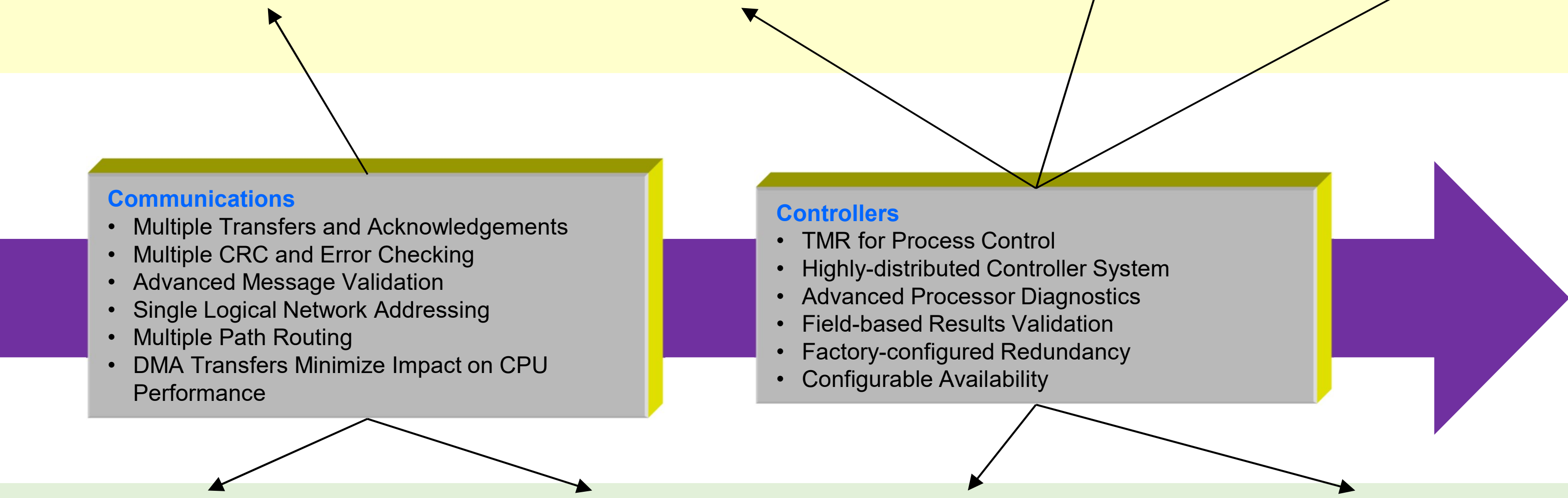
In Run Mode the Node Processors solve the control logic and communicate with each other through the Interlink. I/O processing is

I/O Bus Redundancy:
I/O bus redundancy is standard on the I/O Chassis Processors via a Fast Ethernet network. Redundant network switches, with redundant power supplies, is employed to ensure high availability. Each Chassis Processor has on-board redundant Fast Ethernet controllers that appear as a single IP address to the 3000 target node, ensuring seamless I/O bus continuity. The system consistently monitors the health of and exercises each I/O bus channel to ensure availability without impacting system performance, and reports errors to allow for corrective action.

Simplified Redundancy:
Unlike other redundant controllers, RTP redundant control systems require no additional programming or modification. Any NetArrays control program can run on a single, to Quad redundant configurations, eliminating the cost and time required to modify the program. Downloading a control program automatically transfers the image to all redundant controllers, eliminating the requirement for multiple downloads and the possible errors associated with them.

Factory Configured:
3000 controllers are factory configured and tested for single, dual, triple and Quad redundant operation. Regardless of the configuration, no extra engineering or programming is required to run in redundant mode.

Redundant Power:
For design flexibility and even higher availability, chassis with dual-redundant power supplies are available. These supplies are proof tested on a regular basis as well insuring that if one fails the other is capable running without a shutdown.



Communications

- Multiple Transfers and Acknowledgements
- Multiple CRC and Error Checking
- Advanced Message Validation
- Single Logical Network Addressing
- Multiple Path Routing
- DMA Transfers Minimize Impact on CPU Performance

Controllers

- TMR for Process Control
- Highly-distributed Controller System
- Advanced Processor Diagnostics
- Field-based Results Validation
- Factory-configured Redundancy
- Configurable Availability

Process Network:
Integrity of network communications between the 3000 and the Supervisory Domain (operator and engineering stations) is ensured by the TCP/IP communications protocol, which includes enhanced CRC protection. Every message between the 3000 and the NetSuite computer contains additional CRC bytes within the message. The target node compares the CRCs in the message to its computed CRCs and sends an acknowledgment back to the PC if they agree. It then accepts the message and executes the function. These additional checks ensure integrity of the downloaded configuration file.

Extra Integrity:
Communications between the 3000 Node Processors and the I/O Chassis Processors are ensured via error checking routines. These communications messages use the same communications protocol with enhanced CRC protection as the Process Network. A message is accepted only after the Chassis Processor indicates that the message is valid. In addition each 3000 Node Processor sends its own message to the Chassis Processors, and the Chassis Processors compare the messages to validate the data. In single-processor 3000 systems, the Node Processor sends its messages twice to the Chassis Processors, and the Chassis Processors compare both copies for validation.

Diagnostics for High Integrity:
All processors can diagnose a failure (e.g. malfunctioning CPU, memory corruption, etc.), and even if the system operates in a single configuration, high integrity performance is still achieved due to the following diagnostics incorporated into RTP controllers:
Dynamic data is duplicated to diagnose corruption in DRAM.
All static data is protected with multiple CRCs to diagnose any corruption in the DRAM. These multiple CRCs are placed at the end of the executables. On each scan cycle, the operation of the all ALUs in each CPU is verified for proper functionality.

Results Validation: The results from each of the redundant Node Processors are passed to the appropriate I/O. The Chassis Processor compares these results and applies a two-out-of-three voting test prior to driving the outputs. If an error or fault is detected, the system drives the I/O based upon the voting result, effectively ignoring the offending Node Processor. If the error was spurious, the system's response is fault tolerant. However, if the error is consistent or pervasive, the system can be configured to shutdown the offending Node Processor based upon user defined logic. Even higher integrity is ensured by RTP's unique field-based voting, which is performed as close to the process as possible. This eliminates any possible transmission errors.

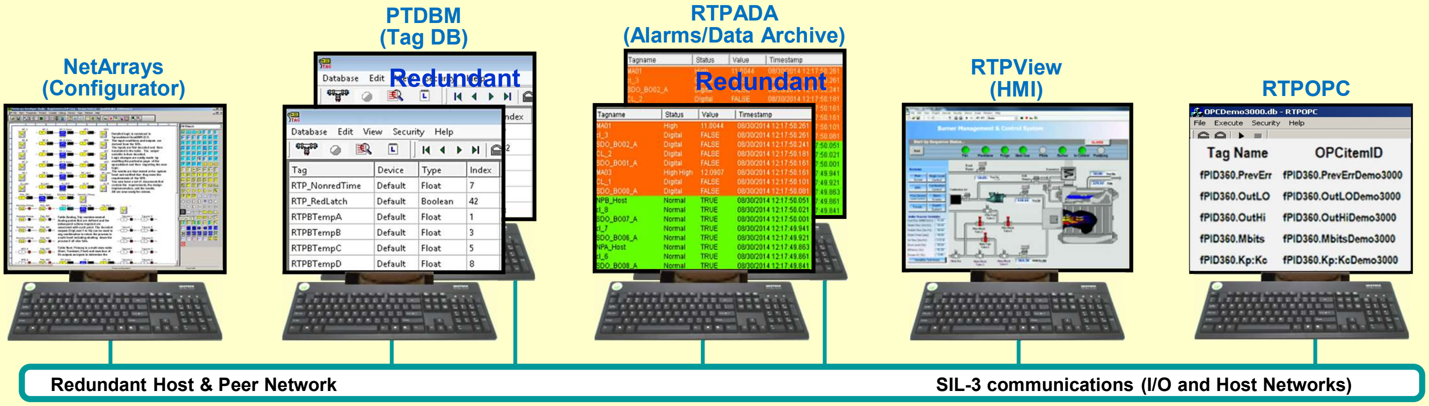
performed concurrently in the Chassis Processors. I/O communications occur at fixed intervals, they are not event driven. The Chassis Processors communicate with the I/O cards via the chassis backplane. Both the Chassis Processors and the I/O cards perform diagnostic tests on the command and data transferred on the chassis backplane. Input measurements from the I/O cards are validated for integrity by the Node Processors using the signal validation configured in NetArrays.

Output control values, computed by the user logic in the Node Processors, undergo comparison tests and voting within the Chassis Processors. This ensures that the correct output is determined before the output value is sent to the I/O card.
All I/O cards perform their own hardware health diagnostics such as checked redundancy of output switches, output readback, input on-state-off-state tests, walking-zero tests, analog calibration and gain tests. Additional diagnostics, such as line supervision and open transducer tests, can detect failures in field devices and field wiring. Field sensor failures can also be diagnosed by the signal validation module.
Peer-to-peer communications, used for distributed computing, have the same diagnostic and integrity checks as the Supervisory Domain communications. Although peer-to-peer communications are event driven, all peer-to-peer data is transmitted at user-defined intervals to ensure the synchronization of distributed peer nodes even if communications errors occur.

RTP NetSuite

- One time Product Registration Fee
- One Development Tool Used for Safety and Control
- Easy to Use PC-Based Graphical Interface
- Redundant Client/Server Design Includes:
  Alarm System, SOE, and Tag Database

- Built-in Fault-Tolerant Redundancy
- No Annual Maintenance Fees
- No Hardware or Software Keys
- Unlimited Number of Installations
- Unlimited Number of Tags



Tag	Device	Type	Index
RTP_NonredTime	Default	Float	7
RTP_RedLatch	Default	Boolean	42
RTPBTempA	Default	Float	1
RTPBTempB	Default	Float	3
RTPBTempC	Default	Float	5
RTPBTempD	Default	Float	8

Tag Name	OPCitemID
fPID360.PrevErr	fPID360.PrevErrDemo3000
fPID360.OutLO	fPID360.OutLODemo3000
fPID360.OutHi	fPID360.OutHiDemo3000
fPID360.Mbits	fPID360.MbitsDemo3000
fPID360.Kp:Kc	fPID360.Kp:KcDemo3000

Totally Integrated Suite of Applications

NetSuite:

Traditional software programming tools for many engineers have proven to be limited in capability and functionality. While the plant may utilize a variety of systems from one manufacturer, the software development tool may vary just as much depending on whether the system application is for safety or control and the size of the system being configured. Added to this may be the complexity of managing multiple databases as one engineer develops logic and another develops the graphics for the HMI. Caution must be taken in the use of tags so as to not exceed the limitation imposed by the software or hardware key. In a continuously running process, there may be changes required to the logic or to the hardware. Unfortunately, there could be a limit to the number and type of changes with no guarantee that the process will not be interrupted if these are done online. Maintaining the system can be a challenge when error codes are presented to the user that has little or no meaning in explaining what or where the fault exists.

RTP has addressed all these concerns and more. Unlike the traditional software programming tools, RTP provides one fully integrated suite of software applications that are used across all platforms and varying applications. The size of the system and number of points configured is not a concern. Utilizing a single database eliminates the complexity of configuring and managing tags. During logic development, why not insure the functionality of the logic and the expected results before the hardware is installed. Simply test and debug the application control logic using the PC based simulator. Simultaneously build the graphics to get a visual of the running process. Implementing a change in logic and even the hardware to the running process poses no problem. Easy access to meaningful diagnostic messages simplifies maintenance and reduces the mean time to isolate and repair faults.

The RTP NetSuite is shown in the opening image above. All of this software may be used on one computer or multiple computers. The first application shown is NetArrays. This is what the engineer uses to define the hardware configuration and develop an application. Additional applications included are the PTDBM - Project Tag Database Manager, RTPADA - Alarm and Data Archiving, RTPView - HMI software, RTPOPC - OPC Server, RTPTSD - Time Synchronize Devices, RTPTrend - Data Trending utility, RTPFIFO - FIFO object Data recorder, and Fuzzy Logic. Not shown above are the different interfaces to get data in and out of the system, ModBus TCP IP and MidBus serial (both ASCII and RTU).

NetSuite Summary:

An integrated system, one control engine, development tool, engineering environment, multiple applications and no HW/SW keys. With a site license you have unlimited use of all the applications shown above. Also, all registered are intitled to receive updates of future releases of NetSuite at no additional cost.

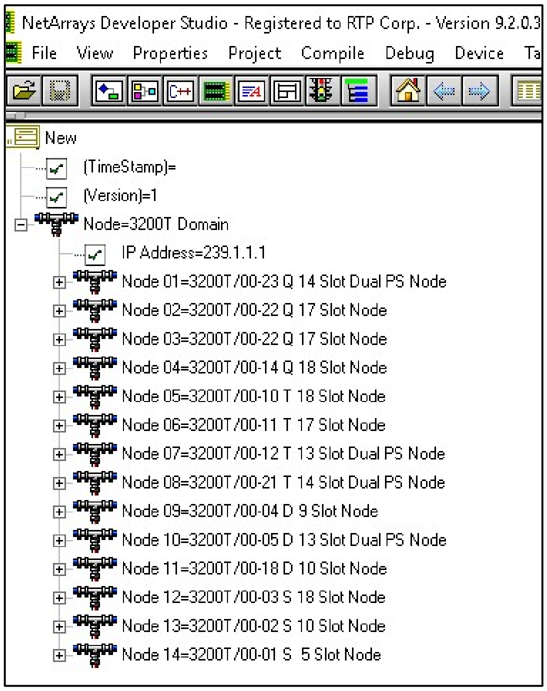
NetArrays:

NetArrays is the project program development software following the IEC 61131-3 standard. It's an easy to use graphical interface that provides:

- Object-Oriented Programming
- Sequential Function Chart
- Ladder Logic
- Batch/State Sequencing
- C++ and Structured Text
- Fuzzy Logic

- Advanced Voting Algorithms
- Unlimited online downloads
- Comprehensive System Diagnostics
- Programs SIF & Critical Control
- PC based Simulator
- 3 Levels of Security

As was stated at the outset, NetArrays is the development tool that is used for all system configurations and applications. The engineer is first required to login with a user name and password to start the application, which is the first level of security. Afterwards, he begins building the project by selecting from a list, the model number of the system to be configured followed by dragging and dropping any additional chassis required and the I/O cards into the slots. With the introduction of the N$^+$ system, the ability to develop the logic for up to 14 nodes in one program has been introduced. These applications are linked together in one program as opposed to the traditional approach of having to develop 14 separate programs. These applications reside in the associated chassis for best response and tighter control thus allowing each chassis to achieve a 1 Msec scan time. When a download of the program is done NetArrays sends the entire program to all 14 Nodes, or however many Nodes are actually configured. Each Node loads only the part of the program associated with its node number.


NetArrays Developer Studio - Registered to RTP Corp. - Version 9.2.0.3
File
View
Properties
Project
Compile
Debug
Device
Ta

New
(TimeStamp)=
(Version)=1
Node=3200T Domain
IP Address=239.1.1.1
Node 01=3200T/00-23 Q 14 Slot Dual PS Node
Node 02=3200T/00-22 Q 17 Slot Node
Node 03=3200T/00-22 Q 17 Slot Node
Node 04=3200T/00-14 Q 18 Slot Node
Node 05=3200T/00-10 T 18 Slot Node
Node 06=3200T/00-11 T 17 Slot Node
Node 07=3200T/00-12 T 13 Slot Dual PS Node
Node 08=3200T/00-21 T 14 Slot Dual PS Node
Node 09=3200T/00-04 D 9 Slot Node
Node 10=3200T/00-05 D 13 Slot Dual PS Node
Node 11=3200T/00-18 D 10 Slot Node
Node 12=3200T/00-03 S 18 Slot Node
Node 13=3200T/00-02 S 10 Slot Node
Node 14=3200T/00-01 S 5 Slot Node

The graphic on the left shows how a Domain can be configured. Each of the 14 nodes can be Quad, Triple, or Dual redundant or a single. Also, you can see that there are 4 different chassis available, 6 slot, 11 slot, and 19 slot with a single power supply and a 15 slot dual power chassis.. The auto tag generator quickly speeds up the naming of tags to be assigned to points. Tag names may also be retrieved from the project tag database (PTDB) if an excel .CSV file was imported. I/O redundancy is as simple as a copy paste operation. Voting of redundant inputs is likewise simplified. There is no writing of complex logic required. A simple drag and drop operation of each redundant input card into the signal validation table (input voting table) populates the table with the redundant hardware channels. It is then just a matter of selecting from a drop-down window, one of twelve different algorithm types to do the voting. A single logical input tag is produced with a status to indicate the quality of the signal. Inputs deemed un-usable are indicated and annunciated. The logical voted input is ready for use in a module form, which brings us to the Main sequence form where the logic is developed. The Main Sequential Function Chart allows the engineer to design safety functions as part of a SIF and or control functions.

These functions may be developed within the same NetArrays application or separately in different applications. Safety functions are developed in secured read-only modules with access to specific functions being granted by the engineer in a specified HMI module. The engineer is provided with an extensive set of over 120 standard predefined objects plus advanced objects to develop the control strategy required. As the engineer does the application development, the PC based simulator allows for testing and verification of the logic independent of hardware. **Breakpoints** are permitted (in simulator only) to step through logic solving and aid in debugging. Debugging within the node processor is permitted under password control, which is the second level of security.

Any logic that is repetitive may be encapsulated in a function form and subsequently copied and re-used where needed. As a result of engineering feedback, there is no limitation on the number of inputs to pass into the function and each instance of the encapsulated subroutine uniquely uses different internal tags. However, any changes made in a subroutine form are globally updated in all copies. This simplifies the copy paste operation allowing quick and easy duplication of logic. Additionally, these encapsulated subroutines may be saved into a library of function forms for easy re-use in future projects which reduces application development time.

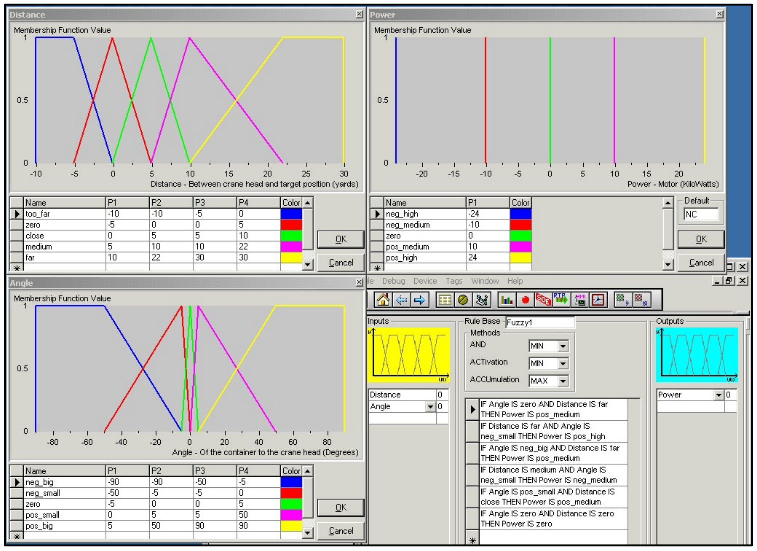
There may be cases where a user-defined function done in C++ or structured text is more advantageous; for example, to do complex algorithms and advanced control functions. These likewise may be tested, verified and then archived in a library of functions for future re-use. All user-defined functions in a project are compiled and built into a single UDF (User Defined Function). The **Intellectual Property** (I/P) of User Defined Functions is protected and can be encapsulated and distributed in separate objects files.

Cause and Effect matrixes are sometimes used in Fire and Gas applications. By using the power of Excel, the C&E Matrix can be entered along with Boolean calculations to allow testing of every possible input condition. The inputs and calculated output results are easily implemented in a few lines of NetArrays logic. The results are then verified at the system level. The engineer now has a set of documents that contain the requirements, the design implementation, and the results and if attached to the NetArrays file will be download with the application and available to be uploaded with the application.

As the engineer continues his development of the application, each time the project is compiled NetArrays runs an error checking routine to determine if any required connection or component file is missing. If so, NetArrays stops the compiler and alerts the developer to the cause, eliminating hours of debugging and searching for the offending error. Additionally, when a project is compiled a **CRC** is created for each page of logic and path flow CRC's are created from the page CRC's. These path flow CRC's are calculated during every scan in the node processor. If the node processor path flow agrees with the compiled CRC's it resets the watchdog timers. If they do not agree the watchdog timers are not reset and the processor will shut down. This insures the programs integrity.

Again, there is no limit to the number of **online downloads** that can be made to a continuous running process. By employing dual memory in the node processor, unlimited changes are possible. If an online change is desired, the download with online update option is selected. These changes may be in logic and hardware and as many times as needed. Each time an online change is made, an upload of the running program is done and a difference file is presented to the user for acknowledgement. This difference file and timestamp is documented into a text file. The new program and difference file is sent down to the node processor where another compare is done to generate a second difference file. If both difference files agree in the node processor, all the current values in the running program are transferred as the initial values of the new program so that the process is uninterrupted. The node is protected against any unauthorized changes by means of password protection, which is the third level of security. Every program download is logged for tracking so you know what changed and when. In some cases, there is an Init module on the Main program page to allow the user to initialize specific variables on the first scan. This initialization should not occur if an online change is being done. The NetArrays object "Online Update" added with the escape object will bypass the initialization logic thereby allowing the change to be made without process interruption.

Another programming language that has gained acceptance, except in safety applications, is Fuzzy Logic. NetArrays implementation includes many of the most popular capabilities. One of the first applications of using fuzzy logic is the movement of a container crane.


Distance
Membership Function Value
1
0.5
0
-10
-5
0
5
10
15
20
25
30
Distance - Between crane head and target position (yards)
OK
Cancel
Power
Membership Function Value
1
0.5
0
-20
-15
-10
-5
0
5
10
15
20
Power - Motor (KiloWatts)
Default
NC
OK
Cancel
Angle
Membership Function Value
1
0.5
0
-80
-60
-40
-20
0
20
40
60
80
Angle - Of the container to the crane head (Degrees)
OK
Cancel
ile
Debug
Device
Tags
Window
Help
Inputs
Rule Base
Fuzzy1
Methods
Outputs

Name	P1	P2	P3	P4	Color
too_far	-10	-10	-5	0	🟦
zero	-5	0	0	5	🟥
close	0	5	5	10	🟩
medium	5	10	10	22	🟪
far	10	22	30	30	🟨

Name	P1	Color
neg_high	-24	🟦
neg_medium	-10	🟥
zero	0	🟩
pos_medium	10	🟪
pos_high	24	🟨

Name	P1	P2	P3	P4	Color
neg_big	-90	-90	-50	-5	🟦
neg_small	-50	-5	-5	0	🟥
zero	-5	0	0	5	🟩
pos_small	0	5	5	50	🟪
pos_big	5	50	90	90	🟨

AND MIN
ACTivation MIN
ACCUmulation MAX

Distance 0
Angle 0

Power 0

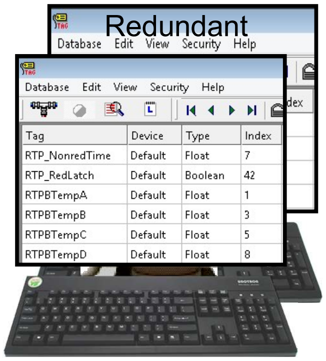
IF Angle IS zero AND Distance IS far THEN Power IS pos_medium
IF Distance IS far AND Angle IS neg_small THEN Power IS pos_high
IF Angle IS neg_big AND Distance IS far THEN Power IS pos_medium
IF Distance IS medium AND Angle IS neg_small THEN Power IS neg_medium
IF Angle IS pos_small AND Distance IS close THEN Power IS pos_medium
IF Angle IS zero AND Distance IS zero THEN Power IS zero

During the container crane movement, the crane mainly has two degrees of freedom of movement, horizontal movement back and forth, and side to side. The lifting direction will lift the container or lower it. The container is grasped by a spreader, and held between the sling and the trolley through multiple sets of wire. When in motion, the spreader would produce swing, and natural attenuation which would last for a long time, and seriously affect the efficiency and safety of cargo handling, so it leads to an anti-swing requirement. The anti-sway control system was divided into two processes, namely, acceleration process and deceleration brake process. During the two processes, different control methods are adopted. This example points out one of the key advantages of fuzzy logic, that is the ability to have multiple inputs and multiple outputs (MIMO).

As can be seen in the picture above, the input description (fuzzy sets) are on the left. with the display of the rules that you want to include in the program in the lower right and finally one of the outputs in the upper right. In this case distance and angle are used to compute the amount of power to be applied. A MIMO application is ideally suited to handle the requirements in the process industry where temperature and pressure are required to be part of the control algorithm.

PTDBM:

The Project Tag Database Manager (PTDBM) provides a central database for device configuration and alphanumeric tags to be used for applications involving a single or multiple nodes. Features include:



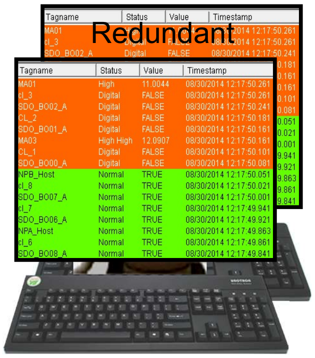
Tag	Device	Type	Index
RTP_NonredTime	Default	Float	7
RTP_RedLatch	Default	Boolean	42
RTPBTempA	Default	Float	1
RTPBTempB	Default	Float	3
RTPBTempC	Default	Float	5
RTPBTempD	Default	Float	8

- Redundancy
- Client-Server Tag Support
- Single Project Tag Database
- Import Export Functionality
- Program modification history and logging
- Tag Management
- Program archive and retrieval

Multiple engineers are able to work simultaneously on different aspects of the project, be it logic or HMI screens. The PTDBM allows these engineers to work in unison using a single database containing a central list of tags and not worry about maintaining different databases and memory addressing inconsistencies. The excel spreadsheet containing the common list of referenced tags may be imported into the PTDBM. These tags become available to the HMI developer as screens are developed and to the application engineer to assign to I/O and logic using NetArrays. New tags may be created in the NetArrays application during development. Each time the application is downloaded to the simulator or node processor, the PTDB is seamlessly updated. Essentially, the project tag database acts as a traffic cop directing tags as they are used. The redundant architecture insures availability in the event the primary database is not accessible. The redundancy may be implemented on the same computer or different computers on the network. The PTDB acts as a tag server to the other applications such as RTPView, RTPADA, RTPTrend, and RTPOPC, which are tag clients. These applications on startup will go to the PTDBM, get the tag location, and then directly communicate with the appropriate device node name, IP address and memory address. The PTDBM ease-of-use and redundant, client/server architecture, eliminates the burden of tag management associated with system integration and at the same time accelerates project development for a smooth commissioning.

RTPADA:

RTP Alarm and Data Archive utility provides truly redundant alarm management, data archival, sequence-of-events and OPC-DA functions. Features provided:



Tagname	Status	Value	Timestamp
MA01	High	11.0044	08/30/2014 12:17:50.261
cl_3	Digital	FALSE	08/30/2014 12:17:50.261
SDO_BO02_A	Digital	FALSE	08/30/2014 12:17:50.241
CL_2	Digital	FALSE	08/30/2014 12:17:50.181
SDO_BO01_A	Digital	FALSE	08/30/2014 12:17:50.161
MA03	High High	12.0907	08/30/2014 12:17:50.161
CL_1	Digital	FALSE	08/30/2014 12:17:50.101
SDO_BO00_A	Digital	FALSE	08/30/2014 12:17:50.081
NPB_Host	Normal	TRUE	08/30/2014 12:17:50.051
cl_8	Normal	TRUE	08/30/2014 12:17:50.021
SDO_BO07_A	Normal	TRUE	08/30/2014 12:17:50.001
cl_7	Normal	TRUE	08/30/2014 12:17:49.941
SDO_BO06_A	Normal	TRUE	08/30/2014 12:17:49.921
NPA_Host	Normal	TRUE	08/30/2014 12:17:49.863
cl_6	Normal	TRUE	08/30/2014 12:17:49.861
SDO_BO08_A	Normal	TRUE	08/30/2014 12:17:49.841

- Redundancy
- Client Server to HMI
- Alarm Management
- System Logging/ History
- 100,000 Tags/Sec Archival
- Trending Archived Data

- Change Driven Data
- OPC enabled third party
- 1ms Analog and Digital SOE recording
- Standard SQL queries
- SIL-3 communications

Engineers and plant operators have a need to monitor, log, prioritize, and acknowledge alarm events. They also need a historian to archive critical process data and sequence of events for troubleshooting, process analysis and to generate reports. Traditional Alarm and Historian applications constantly poll at a specified rate to acquire this data. The problem with this approach is that an alarm or process change could be missed depending on when it occurred, its frequency and duration. The resolution of the data could likewise be impacted by the polling rate and increased network traffic. Added to this is the possibility that the hard disk on the PC could crash. That would be catastrophic.

RTP has addressed these concerns and more. The RTPADA system employs data service, which means the node processors receive from RTPADA the list of alarm and process variables to service. The number of nodes sending the changed data can flood the PC with information faster than it can be processed. Therefore, a configurable polling parameter is added which allows the PC to request the list of changes at a rate that is feasible to process the information that is sent from the node processors.

The node reports the data value, with time stamp, when requested if the value has changed since the last request. High speed 1 msec resolution is provided for both analog and digital SOE as these changes are time stamped and stored in SOE buffers that reside in the processors. They will be reported to both the primary and secondary RTPADA systems if redundancy is used.

Each node processor in a redundant configuration establishes a data service connection to RTPADA and sends point data to the PC's running RTPADA. The list created in RTPADA resides in each redundant node processor and are updated during each scan cycle. Therefore, the redundancy is at the RTPADA PC level and at the node processor level. The alarms are truly redundant at all levels so there is no possibility any alarms will be missed.

The RTP alarm and data archive configuration is quick and simple to setup. Just complete the template provided in the excel spreadsheet and import the configuration. If you have to add new tags to the list, a simple mouse click connects you to every tag in the central project tag database. Filter the list to select and add the tags needed.

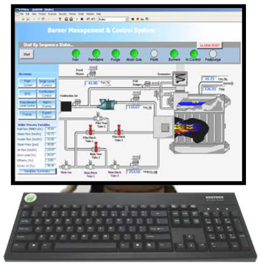
Additionally, RTPADA serves the associated RTPView HMI. In an alarm condition, RTPADA activates an alarm icon within RTPView. When the operator selects the icon, RTPADA serves alarm data to RTPView in a pop-up window. Optionally the alarm window can be embedded into the HMI screens. The server functionality of RTPADA eliminates the need to configure alarming within the HMI, saving time and reducing complexity.

RTPADA lets you record and store process variables in archive files for virtually unlimited archiving requirements. It can be run on one or more workstations, to retrieve process variables from multiple RTP nodes running different control programs. Each node generates system messages to display its history, warnings and errors. RTPADA captures these messages in the system log file and archives them thus simplifying troubleshooting efforts.

RTPADA may also alarm and archive data provided by third party devices. It has a client interface for OPC-DA 2.0. These tags from a third-party device are archived and alarmed along with RTP data. These tags are accessible from the OPC server and the RTPADA acts as an OPC client, just as the RTPView application does. Record high-resolution data to supplement plant historians, or use RTPADA in lieu of a plant historian.

RTPView:

RTPView allows the engineer to create and run the Human-Machine Interface (HMI) project to monitor and control the automated plant processes. Features provided:



- Integrated to PTDBM
- Touch Screen Compatibility
- OPC enabled third Party Support
- Scripting
- Alarm management
- System Error Reporting
- Multiple monitor support
- Video Streaming
- 32 Levels of Security
- 10 msec Screen Update Rate
- SIL-3 Communications

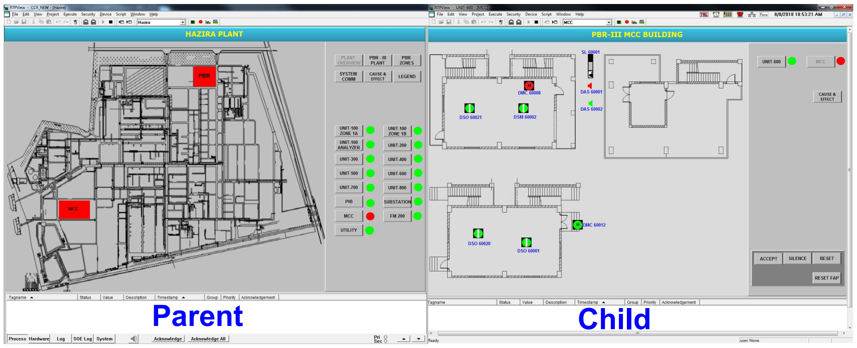
Traditional HMI software applications are complicated and complex to use. It is segmented into engineering software, runtime software and then further segmented depending on the size of the application and number of points. Other desired features may be considered as add-ons if the user needs to have OPC connectivity, scripting, historian and alarm management capability.

RTP has provided the engineer with an integrated solution that includes all these features and more at no extra cost. Developers can design sophisticated animated graphics using its library of over 1500 images. There is no limit in images as user-created bit mapped images and background images may be added to this library.

That means CAD drawings of the plant and plant process as well as any third-party HMI screens can easily be saved as a bitmap file with the texts and object animation overlaid on top. Additionally, RTPView is OPC-enabled, allowing easy connectivity to other systems or devices via OPC-DA 2.0 or UA. Scripting is supported to include mathematical equations, complex control loops, and conditional blocks. RTPView scripts follow the syntax and semantics of Microsoft VBScript ©.

Traditional HMI software applications are complicated and complex to use. It is segmented into engineering software, runtime software and then further segmented depending on the size of the application and number of points. Other desired features may be considered as add-ons if the user needs to have OPC connectivity, scripting, historian and alarm management capability.

Multiple copies of RTPView can be executed on a single operator station, or on operator stations throughout the plant, there are no restrictions.



Feedback received from engineers is that operators in a control room need to quickly access various areas of the plant when an event or alarm takes place and to have this displayed on a secondary monitor. RTP responded with a multiple monitor solution. Each area of the plant is developed independently in a separate RTPView project, which we will refer to as a child project.

The master RTPView project or the parent would contain the plant overview and a button to activate each child project to be displayed on the designated monitor for operator navigation right down to the area and point of interest. As the operator selects other areas in the plant overview project to be displayed, RTPView will automatically close the previous project and open the new one on the designated monitor. Closing the parent RTPView project will automatically close the child applications.

Video streaming: This product enhancement is the result of RTP's responsiveness to the customer requirement to implement streaming video from Pelco's cameras into the RTPView HMI operator stations as part of a complex fire and gas system installation at one of the largest oil refineries in the world. Integrating video into the process HMI can significantly reduce the amount of display stations in the control room, saving money, and streamlining your operations. With streaming video integrated into the standard process HMI, the operator can take advantage of the enhanced view provided by the real-time video to quickly assess the process situation, thereby reducing the time spent responding to false alarms. RTPView incorporates support for displaying streaming video from Pelco's or other IP cameras utilizing the latest high-quality H.264 video compression standard. The RTP implementation seamlessly integrates the IP camera's video stream into RTPView HMI.

RTP satisfied engineering requirements for operator write confirmations by adding a configurable option in the data property of an RTPView tag that enables a pop-up box requesting confirmation of a new changed value automatically. No scripting is required. The touch screen numeric input also added per a customer request has range checking to prevent incorrect entries. Again, no additional programming or scripting is required.

RTPView connects as a client to the RTP Alarm and Data Archive server. Each RTPView HMI workstation displays alarm conditions and system status messages from RTPADA in real time and no alarms or messages are ever missed. Alarms may be displayed, silenced, and acknowledged directly from the HMI workstations.

RTPOPC:

The RTP OPC Server works in conjunction with other RTP applications and third-party software packages to provide RTP I/O data in the open OPC-DA 2.0 and OPC UA environment.

Tag Name	Device	OPCitemID
fPID360.PrevErr	Demo3000	Demo3000.fPID360.
fPID360.OutLo	Demo3000	Demo3000.fPID360.
fPID360.OutHi	Demo3000	Demo3000.fPID360.
fPID360.MBits	Demo3000	Demo3000.fPID360.
fPID360.Kp:Kc	Demo3000	Demo3000.fPID360.
fPID439.PrevPV	Demo3000	Demo3000.fPID439.
fPID360.Ki:Ti	Demo3000	Demo3000.fPID360.
fPID390.ITerm	Demo3000	Demo3000.fPID390.

- Integrated to PTDBM
- Change Driven Data
- Data and Quality monitoring
- Third Party OPC client support
- SIL-3 communications

Unlike many OPC servers, the RTP OPC server is written using the COM free threading model. OPC clients that have implemented the free threading model will not block requests from other clients. Lower priority clients do not affect higher priority clients. The OPC server uses a separate thread for each point group. Threads in the same OPC client using different point groups will not block each other. This allows client software to fully benefit from parallel processing and multi-threading using the COM free threading model. This technology is what enables the high performance of the RTP OPC server. The RTP system can utilize redundant networks for increased availability.

The OPC Server is able to reside on the same PC with any of the NetSuite applications. The OPC Server can read data from multiple RTP I/O Nodes. The information is available to multiple OPC compatible clients residing on the local PC.

RTPTrend:

Data analysis and troubleshooting of the live process is made easy with the RTPTrend software. Live data trending does a plot of the process variables value and time. Added to the plot is a table below to display the tag, value, time, and min, max. You can add a scale, offset and zoom to any channel. Pause the trend and you can enable the cursor to get the exact value and time of a transient. Expand or compress the chart to amplify the point of interest or evaluate it over time. You can even add a timestamp to the point on the chart. You may graphically plot up to 10 traces in a variety of pen colors.

RTPTSD:

The number of nodes on a network is unlimited. Each node timestamps all messages including errors, alarm data, archive data, analog and digital SOE data. The RTPTSD (Time Synchronize Devices) application will synchronize the time of any and all selected node processors on the network with the local computer time. If continuous synchronization is required, the engineer is able to select the update rate for synchronization. All of the aforementioned applications are included in one software suite at a tremendous savings. Updates to any and all applications in the suite are provided at no cost. The one-time software registration fee provides unlimited points on unlimited stations and unlimited installations at the site. Gone are expensive software maintenance costs, bothersome hardware and software keys. Engineers are equipped to design, develop, deploy, commission, and maintain the critical control and/or safety system at a fraction of the time and a fraction of the cost.

Listed below are some of RTP's customers.

AEP
Chevron Phillips Chemical Company LP
ONTARIO POWER GENERATION
bp
PEMEX
HEXION Specialty Chemicals
Thaioil
CFE Comisión Federal de Electricidad
Eni
इंडियनऑयल IndianOil
Zuari Cement Italcementi Group
aps
Bruce Power
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
ONGC एनआरपीएल MRPL
MAHAGENCO Maharashtra State Power Generation Co. LTD.
VALERO
CALUMET SPECIALTY PRODUCTS PARTNERS, L.P.
PetroChina
ExxonMobil Chemical
Candu
PMV Petroquimica Mexicana de Vinilo
DUKE ENERGY
Entergy
Xcel Energy
Dominion
ppl PPL Electric Utilities
Reliance Industries Limited
Chevron
SOUTHERN COMPANY
OXY
Luminant
AECL
SCANA POWER FOR LIVING
PHILLIPS 66
FirstEnergy
Celanese
BOREALIS
PSEG
ConocoPhillips

Trademark acknowledgements: RTP is a registered trademark of RTP Corp. All other product or service names mentioned herein are trademarks of their respective owners. Specifications and information are subject to change without notice. Contact RTP's corporate office for the latest specifications.

All information, data, graphics and statements in this document are proprietary intellectual property of RTP Corp. unless otherwise indicated and are to be considered RTP Corp. confidential. This intellectual property is made available solely for the direct use of potential or licensed RTP Corp. customers in their application of RTP Corp. products, and any other use or distribution is expressly prohibited. If you have received this publication in error, immediately delete, discard or return all copies to RTP Corp.