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An Extension of PDXI Data Models to Include Process Control Data

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ABSTRACT

The results described herein have culminated into the creation of an object model which extends an existing engineering data model to include process control data. The existing data model is described in Volume I of the deliverables for the Process Data Exchange Institute(PDXI) Data File Interchange Format Project. This object model was created using the OMTool® software package on Sun Stations in the Intelligent Systems Center(ISC) of the University of Missouri-Rolla(UMR). It expands on the classes of signal port, control element, and control system.

INTRODUCTION

These models have been created for the Process Data Exchange Institute, a consortium of thirty companies in the process industries. The following is a detailed explanation of the object modelling results for the three classes of signal port, control element, and control system. These models are reflected in figures 1,2 and 3 respectively.

PROJECT RESULTS

The classes of signal port, control element, and control system have unique and individual models. These models expand upon the makeup, attributes, and definition of each class. Signal port is a portion of a process plant equipment boundary through which a signal is intended to flow; a port is the portion of a process plant equipment boundary through which material, energy, or signals can flow. Control element is the wetted portion of a process plant equipment which senses or varies process fluid parameters. Control system is a type of process plant equipment that has as a principle function the generation, transmission, indication, and/or manipulation of signals. Control systems are not intended to be in contact with process material and do not include sensors and actuators(control elements). [Process Data Exchange Institute, 1993]

Signal Port

Signal ports may carry electrical or pneumatic signals. Each of these signals has a transmission method which describes the occurrence of the signal, be it discrete or continuous. Signal purpose, another enumeration of these signal types, may be defined as either measurement(such as a pressure signal for a pressure gauge), or manipulation(such as a pressure signal which actuates a valve). One attribute of these signals is lag time, which represents the time between signal transmission and reception from the exiting port defined for the transmitting entity to the reception port defined for the receiving entity. An electrical signal can be an amperage, digital, or voltage signal. An amperage signal is a signal which embodies amperage flow. An ampere is the unique amount of current which causes a force of 2×10^{-7} newton(for each meter of length) between two long parallel wires in free space separated by one meter[Considine, 1974]. A digital signal is a signal carrying discrete numerical values which have the attributes of a certain number of bits and a parity designation. A bit is a quantitative unit of digital signal capacity. Parity is a designation carried by each group of eight bits which specifies the sign designation of numbers contained in the eight bits. A voltage signal is a signal which occurs when voltage, an electrical potential caused by a relative build up of electrons, travels through a medium. A voltage signal has a specified range of output, and amperage has a standard range between 3 and 20 mA. Voltage signals may be either alternating or direct current signals. An alternating current signal has a voltage whose polarity alternates regularly at a specific rate known as the cycle time. A direct current voltage signal does not have a polarity alternation, but rather maintains constant polarity.

Control Element

A control element has a control type, purpose, and transmission. The control type is an enumerated variable which may be electrochemical, photometric, or chromatographic[Nichols, 1988]. The purpose is a rational for existence and may either be practicality or safety. Transmission specifies the type of signal, be it discrete or continuous. There may be one or many controlled entities for every one or many control elements. A controlled entity is the process fluid which is monitored and/or manipulated by a control element. Control elements include actuators and sensors. An actuator alters process fluid flow for control purposes, while a sensor collects process fluid control data to be compared with a set point. Actuators and sensors specified herein are only those components wetted by the process fluid. This specification is made to avoid confusion with process plumbing system models. A sensor may be a thermometer, or pressure transducer[Benedict, 1977]. A thermometer measures object or fluid temperature at a particular location. A pressure transducer is a device which senses and transmits a pressure signal, utilizing electricity. Also, every pressure transducer may need one or no electrical ports.

Control System

A control system may be specified by a location. A control system may be a signal carrier, readout, or controller. A signal carrier is an entity, usually having two ports, which is a medium of signal transfer. A signal carrier may be a wire, pneumatic tubing, or fiber optic cable. A wire, a signal carrier which is a medium for a particular electrical signal, has a specific capacity. This capacity is the voltage within-which a specific wire can safely and properly operate. Pneumatic tubing, tubing which carries a pressure signal, has a pressure range and signal purpose. This pressure range is the span of pressures within which a pressure signal can be safely carried. Furthermore, the signal purpose may be either pressure reading or actuation. Fiber optic cable is defined as a medium of data transfer which utilizes light signals and photometric sensors. Fiber optic cable has a data capacity, which represents the maximum rate of data transfer which can be realized in the fiber optic cable itself. A readout, a source of data on process control status which may be heard or seen, can be designated by specifying range, type of range, and span[Considine, 1974]. Range is the domain over which a specific readout can measure a process variable's value. Type of range is an enumeration of the readout class which includes measured variables, measured signals, and scales. Span represents the algebraic difference between the upper and lower range values[Andrew, 1974]. A readout may be a strip chart recorder, visual meter, or computer. A strip chart recorder is a device which chronologically records data, usually implementing time as the x-axis and the process variable(data) as the y-axis. A visual meter displays process variable values in a visual manner, but has no recording apparatus. A computer is an electronic device which receives commands and data, performs manipulations, and then generates feedback in the form of an image on a monitor or a printing device. A computer has a mega-hertz(mhz) which represents the processing speed of the central processing unit(CPU), and random access memory(RAM) which can be accessed for data storage and reading or complex manipulations.

DISCUSSION

Unresolved questions about this model include where alarms should fit into the control system model and also whether or not the control system should represent all control devices for a particular controlled variable. The alternative for control system is that it would individually represent single control devices such as the signal generator, comparator and compensator. Moreover, alarms may be considered a type of readout or a unique control system class. Possibly a control system sub-class such as "process safety" could be implemented to include control system alarms. Using a wetted portion to distinguish between control elements and plumbing has been resolved as a good concept. The basic classes and subclasses have been designated, but some expansion is warranted in these items as well as the attributes. Additional control system sub-classes to consider may be signal transducers such as P/I, D/A, A/D, and I/P; signal generators; and controllers such as algorithmic, proportional, proportional-integral, and proportional-integral-derivative. Moreover, the actuator sub-class may be broken into sub-classes such as valves, resistors, and electrical switches. Some attributes to consider adding include length, gauge, insulation material, and insulation thickness for wire; as well as chart speed and paper width for strip chart recorders. I recommend that this document be submitted to a knowledgeable firm for a final evaluation.

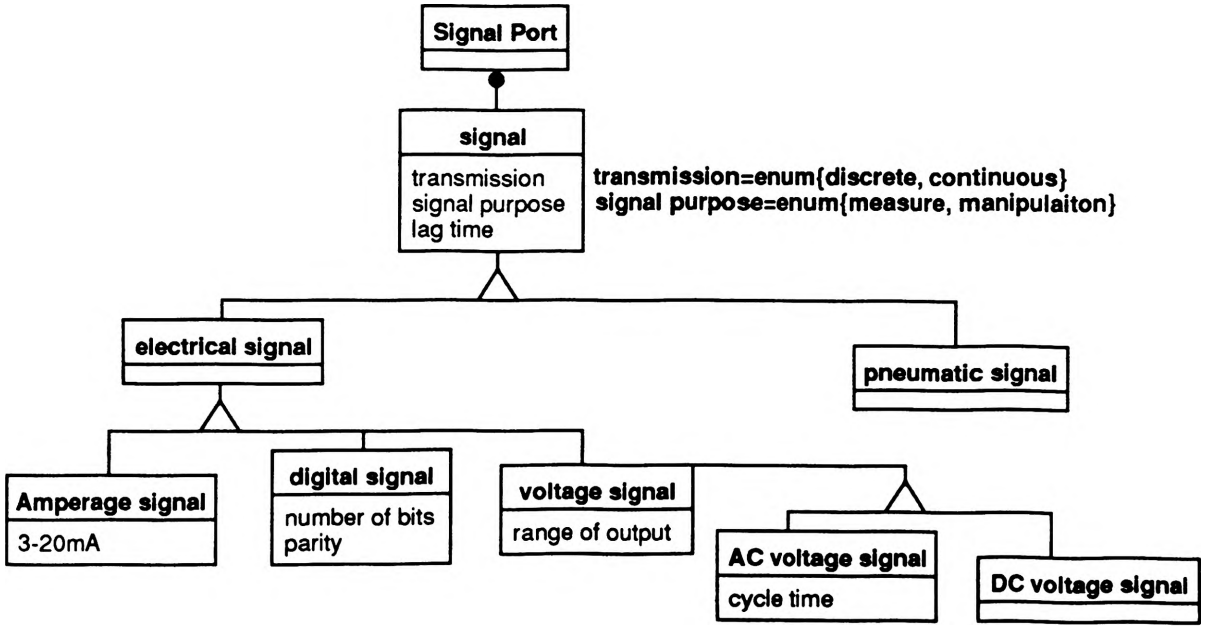


Figure 1. Signal Port Panel

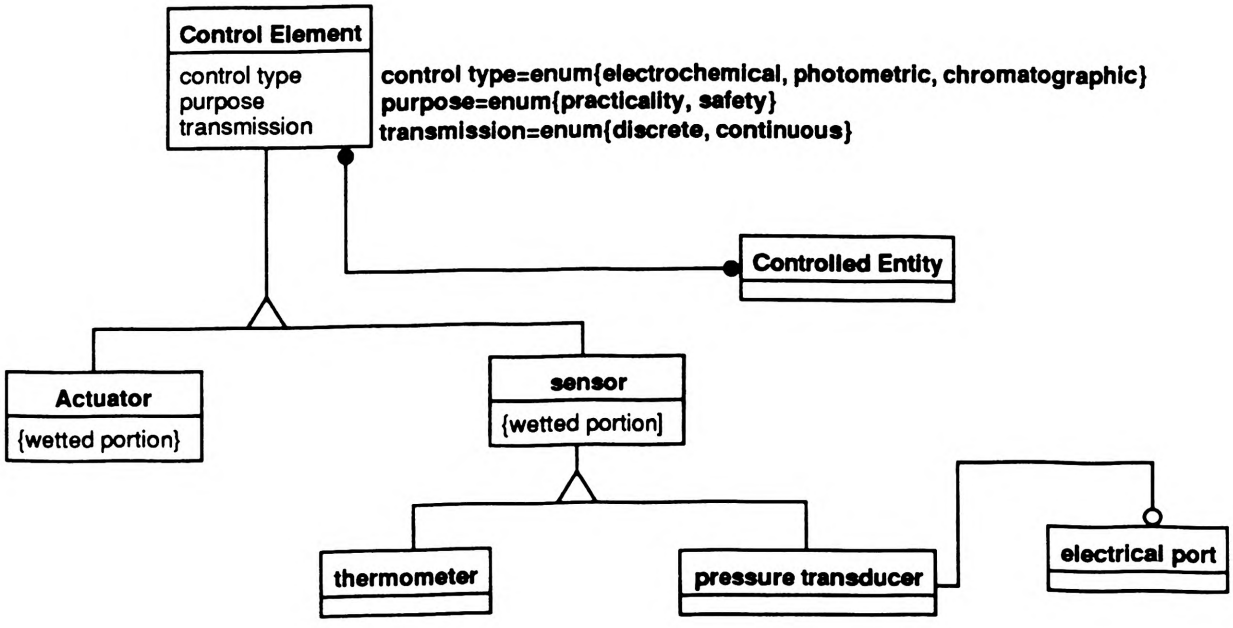
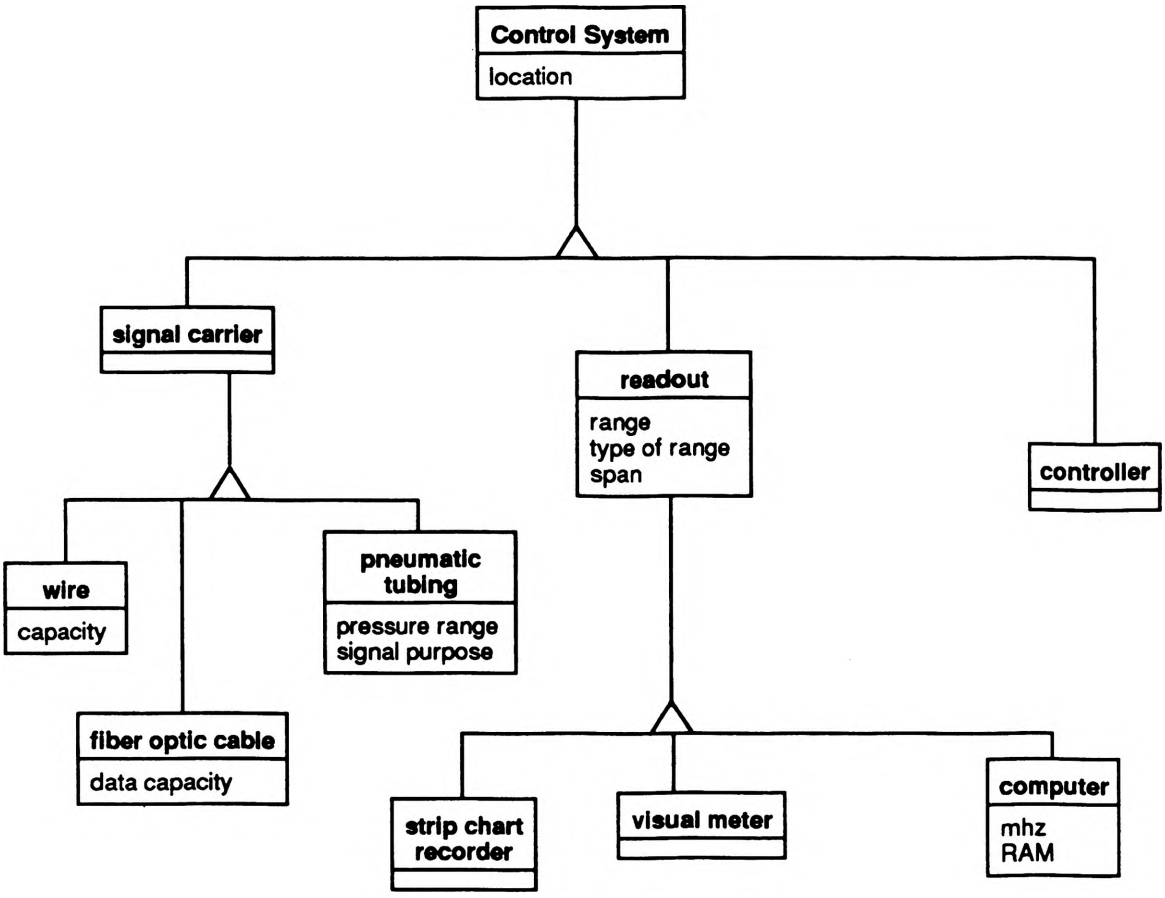


Figure 2. Control Element Panel



signal purpose=enum{pressure reading, actuation}
type of range=enum{measured variable, measured signal, scale}

Figure 3. Control System Panel

AC VOLTAGE SIGNAL A voltage signal whose polarity is constantly alternating with a specific cycle time.

AC VOLTAGE SIGNAL.cycle time The time required for one alternation cycle of an AC VOLTAGE signal.

ACTUATOR A wetted control element which alters the process fluid flow for control purposes.

AMPERAGE SIGNAL A signal which constitutes a magnitude of flow of a current.

COMPUTER An electronic device which receives commands and data, performs manipulations, and then generates feedback in the form of an image on a monitor or printer.

COMPUTER.mhz The megahertz of a COMPUTER, representing the processing time of the CPU.

COMPUTER.ram A type of computer memory which can be accessed for data storage and reading or complex manipulations.

CONTROL ELEMENT The wetted portion of a CONTROL SYSTEM which senses or varies process fluid.

CONTROL ELEMENT.control type An Enumerated variable which may be electrochemical, photometric, or chromatographic.

CONTROL ELEMENT.purpose A control element's rational for existence: practicality or safety.

CONTROL ELEMENT.transmission The type of signal which is directly involved with a control element's port. Transmission is an enumerated variable which may be discrete or continuous.

CONTROL SYSTEM A type of process equipment that has as a principle function the generation, transmission, indication, and/or manipulation of signals. Control systems are not intended to be in contact with the process material and do not include sensors and actuators.

CONTROL SYSTEM.location The room or coordinates of a control system within a specified plant site.

CONTROLLED ENTITY The process fluid which is monitored and/or manipulated by a control element.

DC VOLTAGE SIGNAL A voltage signal whose polarity does not change in time.

DIGITAL SIGNAL A signal carrying discrete numerical values contained in bits.

DIGITAL SIGNAL.number of bits A quantitative unit of digital signal capacity.

DIGITAL SIGNAL.parity A signal unique to each numerical byte(8 bits) which gives a sign specification for the bits.

ELECTRICAL PORT A port which carries an electrical potential.

ELECTRICAL SIGNAL A signal which involves the rearrangement of electrons in a conducting media.

FIBER OPTIC CABLE A medium of data transfer which utilizes light signals and photometric sensors.

FIBER OPTIC CABLE.data capacity A maximum rate of data transfer through a fiber optic cable.

PNEUMATIC SIGNAL A signal whose medium of transfer is a pressure differential.

PNEUMATIC TUBING Tubing which carries a pneumatic signal of a specific range and purpose.

PNEUMATIC TUBING.pressure range The rated pressure range over which signals can be safely carried.

PNEUMATIC TUBING.signal purpose Pneumatic Tubing's rational for existence: pressure reading or actuation.

PRESSURE TRANSDUCER A device which senses and transmits a pressure signal utilizing electricity.

READOUT A source of data on process control status which may be heard or seen.

READOUT.range The numerical domain over which a specific readout can measure a process variable's value. This entity is specified by an upper and a lower boundary value.

READOUT.span The algebraic difference between upper and lower boundary values which are specified by the range.

READOUT.type of range An enumerated variable which may be a measured variable(°F), measured signal(mV), or scale(lb/hour).

SENSOR A device which collects process fluid control data to be compared with a given set point.

SIGNAL A message, energy, or force sent along some medium for control purposes.

SIGNAL.lag time The time between signal transmission and signal reception from port to port.

SIGNAL.signal purpose The reason for a signal: measure or manipulation.
SIGNAL.transmission The occurrence of a signal: discrete or continuous.
SIGNAL CARRIER An entity usually having two ports which is a medium of signal transmission(ie. wire).
SIGNAL PORT A portion of a process plant equipment boundary through which a signal is intended to flow.
STRIP CHART RECORDER A device which chronologically records data(a graph of data vs. time).
THERMOMETER A device which measures object or fluid temperature at particular location and time.
VISUAL METER A type of readout which can be read visually but has no recording apparatus.
VOLTAGE SIGNAL The electrical potential caused by a relative build up of electrons at a site.
VOLTAGE SIGNAL.range of output the voltage range within which a particular voltage signal functions.
WIRE A signal carrier which is the medium of a particular electrical signal.
WIRE.capacity The voltage within-which a specific wire can safely and properly operate.

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REFERENCES

Andrew, W. G., Applied Instrumentation in the Process Industries, Volume 1 A Survey, Gulf Publishing Company, Houston, 1974.

Benedict, Robert P., Fundamentals of Temperature, Pressure and Flow Measurements, 2nd ed., John Wiley & Sons, New York, 1977.

Nichols, Gary D., On-Line Process Analyzers, Wiley Interscience, New York, 1988.

Considine, Douglas M., Process Instruments and Controls Handbook, 2nd ed., McGraw-Hill Book Company, St. Louis, 1974.

Process Data Exchange Institute, The PDXI Data Models, Phase I Final Draft, American Institute of Chemical Engineers, New York, 1993.