Integrated Systems Design

for contract

“Enabling Technology for Human Collaboration”

issued based on RFQ 4955

submitted to

Advanced Concepts Group
Sandia National Laboratories
Albuquerque, NM 87185

by

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Table of Contents

Summary

This document describes an integrated systems design, including computer network hardware, software, sensor equipment, support equipment, and utility specifications to enable a four-person prototype system to be assembled in the Sandia Advanced Concepts Group game room or equivalent facility at the Sandia National Laboratories site in New Mexico. The integrated systems design incorporates safety advisory information for Project Manager review.

Quad Pod 4-person collaborative workstation with physiological monitoring capabilities.

Introduction

A general focus of MindTel's activities has been the pioneering of new methods of physiologically based human-computer interaction, specifically for quantitative human-performance assessment. This capability promises to be a powerful tool for characterizing the complex nature of normal and impaired human performance, enabling researchers to explore new methods of interaction and analysis. Such quantitative measurement of activity during purposeful tasks allows us to quantitatively characterize individual cognitive styles.
Fusion of sensor data with user interaction parameters will allow meaningful correlations to be made across various performance modalities. To this end, we will embrace modular design for the integration of several data input devices into a single platform within a common interface protocol.

In order to refine quantitative measurement of activity during purposeful collaborative tasks, we plan to develop and integrate a set of advanced human-to-computer input devices into a single interface system and to provide an open hardware platform and modular infrastructure that will expedite the implementation of new technologies into the system. That system is designed to be scalable, extensible, interoperable, and modular at a fundamental component level. Specifically, we are developing a "reference architecture" (a formalized conceptual framework for technology development) for designing physio-informatically robust, interactive, human-computer interface systems. The reference architecture we are developing will have the necessary complexity to be able to address the physiological issues in an interactive human-computer interface system.

The experiential and experimental basis for this work comes from the researchers' extensive experience in developing interface technologies for persons with severe disabilities and from the DARPA programs for instrumenting humans for controlling distributed robotics and remote computer systems.

It is MindTel's understanding that the scope and level of effort of this project are to develop an initial operational four-person collaborative system with the following functions, features, and requirements.

Functionality

The delivered prototype system is to have the following demonstrable initial functionality:

1. real-time data acquisition from multiple simultaneous sources (biosensors and interface devices; initial set to be determined in design phase)
2. archival and timed-stamped data storage of complete data set acquired
3. real-time data analysis (to be determined in the design phase)
4. display of individual and combined sensor and data analysis simultaneously from multiple participants
5. voice-activated operation of standard Internet navigation and search operations
6. one hour of continuous operation
7. contractor's availability to assist with experimentation as needed by Sandia

Scope

To ensure agreement on scope, scale, and context of development effort, MindTel has proposed the following design of an integrated system with all hardware, software, sensors and overall functionality specified (the system):

1. Integration of all components and functionality will commence as soon as the design is accepted after integration and testing an operational system be delivered and demonstrated at Sandia Laboratories.
2. The initial goal is to have a fully operational system with all core components functional.
3. Fully operational implies the ability to collect and store an array of sensors monitoring each collaborators physiologic and interaction performance data during a one hour directed collaboration effort. Initial data streams include direct physiological data, data from other user-activity-monitoring devices, and data from traditional input devices. There is also the ability to stream specific data to a supervisor, observer, or session monitor for near real-time analysis.

“Quad Pod”

An instrumented collaboration station (Quad Pod) will be equipped with networked computers and interface systems for tracking four simultaneous users (Quad Squad) during directed collaborative activities. Some specifics of the system are as follows:

1. The system will be able to simultaneously track and record multiple data streams from four individuals in a group collaborative.
2. Each of the collaborative participants will have his or her own computer and interface system.
3. The initial system is designed for use in a fixed setting doing a specified task.
4. Four participants are seated in a common area (at a round table) engaged in a purposeful collaborative interaction (http://www.ideationsllc.com/projects/sandia2003/quadpod/quadpod-Pages/Image38.html).
5. Each person has a computer and display for collaborative interaction.
6. Each computer has a user-monitoring system consisting of an array of interface options that can be used in combination to monitor user dynamics corresponding to task-specific activities.
7. A combination of natural, spontaneous biosignals and task-specific actions will be monitored.
8. Each interface system will capture and stream data from the user. The user interface consists of the physio-sensors, electro-mechanical sensors , microphone, face camera, mouse, keyboard, and joystick.
9. The four collaborators computers will stream data to a common server for time-locked data storage, analysis and, post processing. The initial capacity of the system will be to be able to record 1 hour of directed collaborative activities.

10. The system must store a reasonably accurate record of all events from all users and the environmental monitors. A realistic range is 500–900 ms.
11. The collaboration station will have a “group” audio and video recording capability.
12. The time locked data from each of the four collaborators, along with the video of the group session will be combined to create a master session record.
13. The maintenance of record integrity is a significant issue. Such integrity is achieved through security protocols, standardized data formats, error handling, and semi-automated database archiving. The data management subsystem tasks also include linking the device data with the record and specifying sensor-specific data formats and structures.
14. The system will allow a supervisor to monitor all data, with eventual real-time access to live streams.
15. The system will be designed so that any data stream or any combination of data streams can be analyzed in near real time.
16. This collective combination of data streams contains sufficient dynamic information to provide insight into the user’s state of being.

Initial Technical Choices

To ensure core functionality of the overall system we will use familiar technology.

Bioelectric signals will be acquired by ProComp Infiniti 8-channel, multi-modality encoders (http://www.thoughttechnology.com). ProComp was chosen for its core functionality, and to ensure maximum safety.

MindTel’s TNG-4 serial interface will host the remaining sensors. TNG-4 is a bidirectional, 28-channel (highly expandable via SPI protocol), analog-digital interface designed to accommodate multiple sensors and controllers (http://qube1.mindtel.com/~edlipson/TNG/TNG-4/TNG4.pdf).

Both ProComp Infiniti and TNG-4 are optoelectrically isolated for safety.

In general this system addresses a multi-sensor multimodal heterogeneous data fusion problem.

Initial efforts will establish a multi-biosensor capacity with an set of direct physiological measurements (noninvasive electrophysiology) of the following signal modalities:

- Brain (electroencephalography, EEG)
- Eye (electro-oculography, EOG)
- Heart (electrocardiography, ECG)
- Breathing (respiration)
- Skin (galvanic skin response, GSR)
- Pulse (blood volume pulse, BVP)

Video of facial expression and gestures, and of eyes of each participant will be tracked for the following:

- Expressional data
- Face (video camera)
- Voice (microphone)

There will also be a set of somatic sensing devices using electromechanical motion sensors for monitoring motion, and position:

- Somatic data
- Body movement (wrist and head, using accelerometers)

Standard computer input devices will be monitored:

- Mouse
- Keyboard
- Touchpad
- Microphone (for voice commands and other sounds)

All input from all devices will be recorded.

Future Research Considerations

The following considerations accommodate ongoing research and refinement:

- The system is designed to be used on an ongoing basis and to support emerging collaborative research protocols.

- The modular design of the system will maximize flexibility for experimental utility.

- The system is designed to be a research tool to enable the exploration of group collaborative dynamics.

- The system is designed so that any data stream or any combination of data streams may be analyzed in near real-time.

- The system is designed so that observers can remotely monitor any activity.

- The system is designed to accommodate emerging technologies that can be added to the system when desired.

- The object-oriented nature of the software ensures maximum flexibility for including new sensors in the future

The initial hardware specification includes the following:

- 5 computers (Shuttle XPC; http://us.shuttle.com)

- 4 interface systems (ProComp Infiniti; for bioelectric sensing; http://www.thoughttechnology.com/procomp.htm)

- 4 TNG-4 serial interfaces (MindTel; for human-interface physical signals; http://qube1.mindtel.com/~edlipson/TNG/TNG-4/TNG4.pdf)

- 4 or more microphones (voice-command recognition and recording)

- 4 or more video cameras (face and facial gesture recognition)

- 1 computer-based audiovisual session-recording system (stereo or mono microphone for each user; and one or more ambient microphones; video cameras, one per user and additional ones for monitoring user interactions; split-screen display)

Initial Software Specification

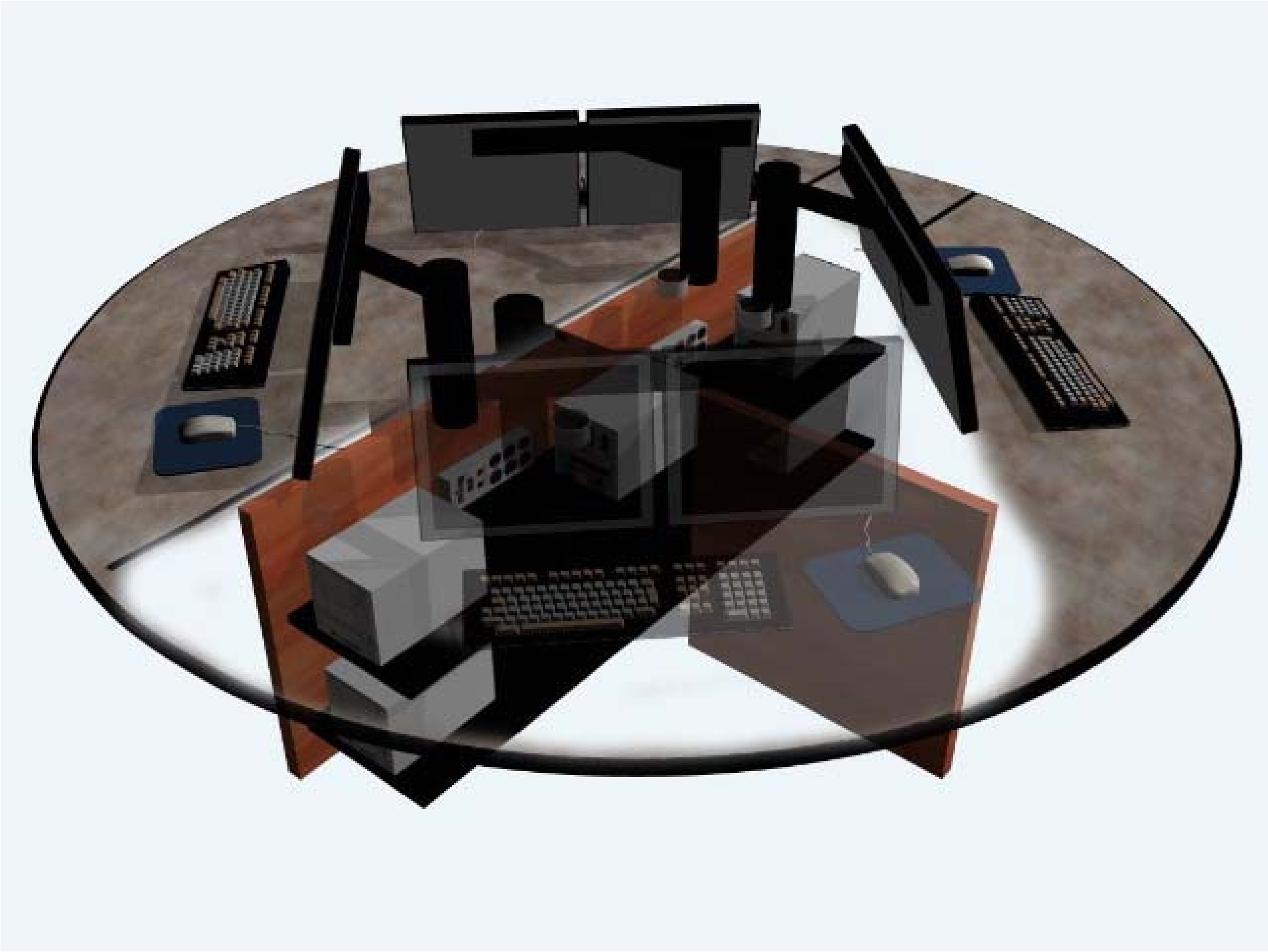
- Microsoft Windows 2000 Professional (operating system)
- NeatTools (human-computer interfacing, data acquisition, sensor integration, and dataflow control; www.pulsar.org/2k/neattools/)

Collaborative Game

- To be determined by Sandia ACG team

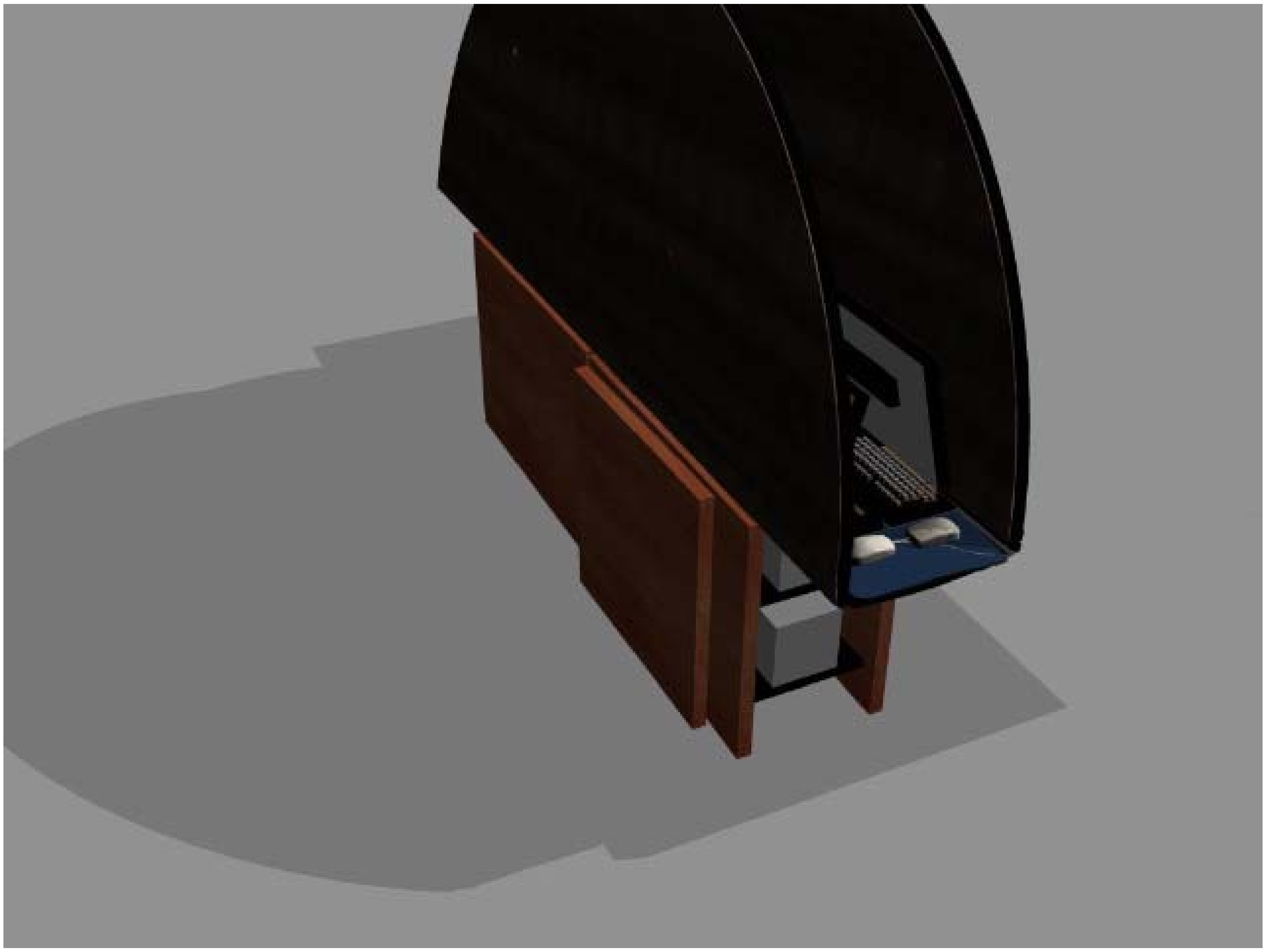
Appendix 1: “Quad Pod” Physical Layout

Quad Pod four-person collaborative workstation with embedded physiological monitoring system for each user.



The 7-foot Diameter round table accomodates 4 users. The 30-inch high table conceals the technology, including one server, four client PCs, power and network distribution, I/O interface boxes, and physiological monitors. The dual LCD displays as well as keyboard and mouse are on top.

Access to frequently used interface systems is conveniently provided by sliding shelves located at opposite ends of the table. Cable management is handled at the back end of each shelf, while all cables connecting the sensors are passed through grommets at the front end of each shelf. During normal operation, the shelves conceal and protect the electronic components.

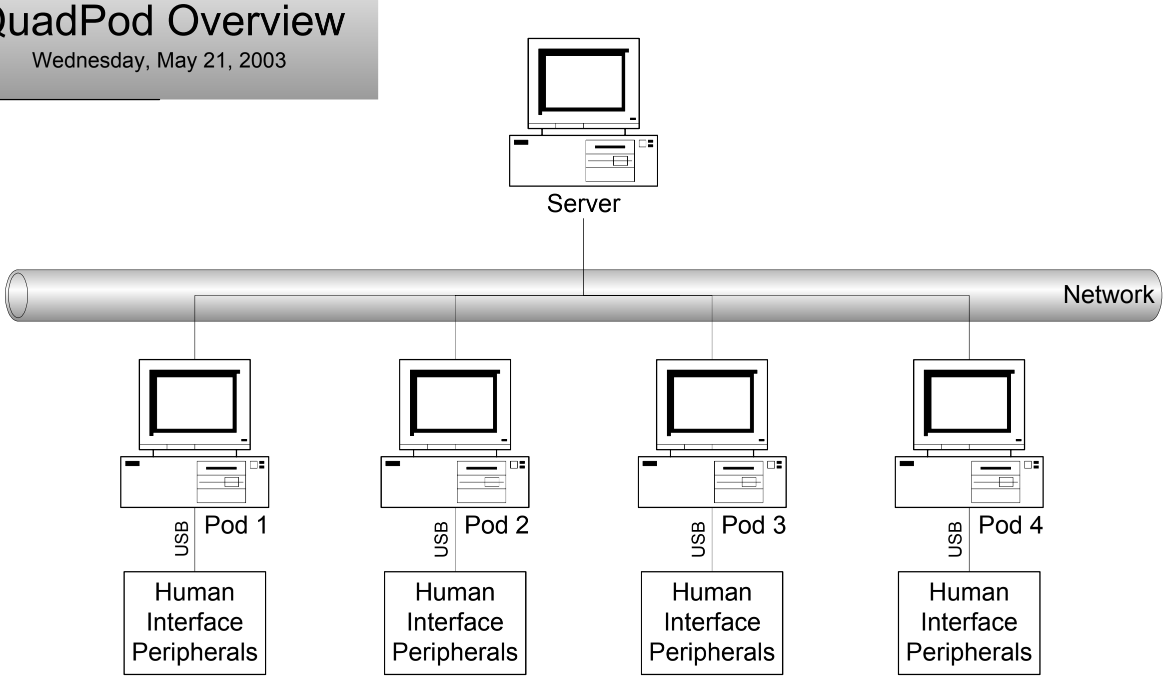


When not in use, the table can be folded up to a footprint of only 18 inches wide by 7 feet long. Keyboards and mice are moved to the center section, while the LCD display panels are pivoted towards the center of the table. The half-round wings are hinged to pivot upwards, encompassing the LCD panels, and the supporting legs are folded in towards the sides of the central structure. All electronic components are secured and well protected by the structure of the table when folded up.

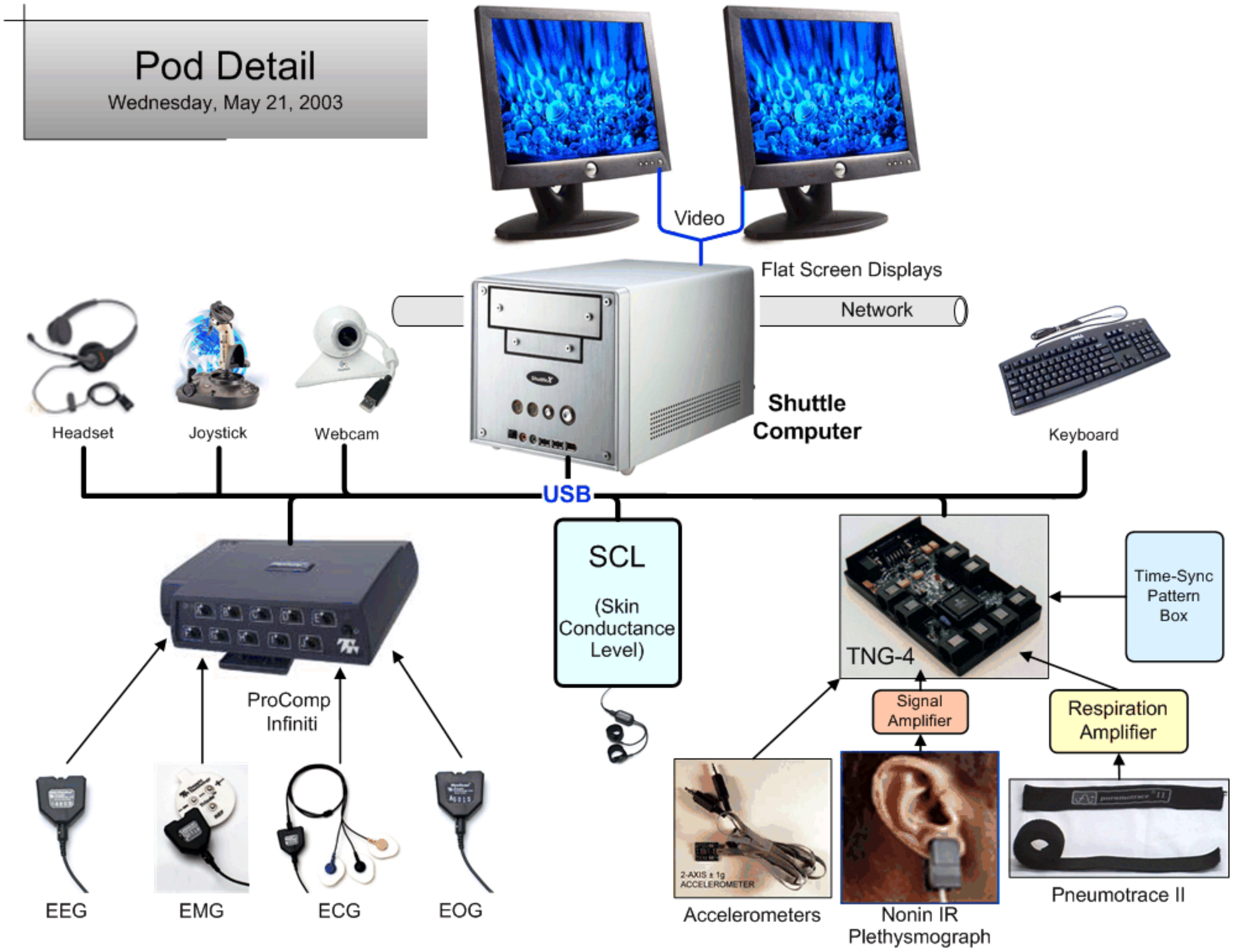
Appendix 2. Quad Pod Technical Schematics

QuadPod Overview

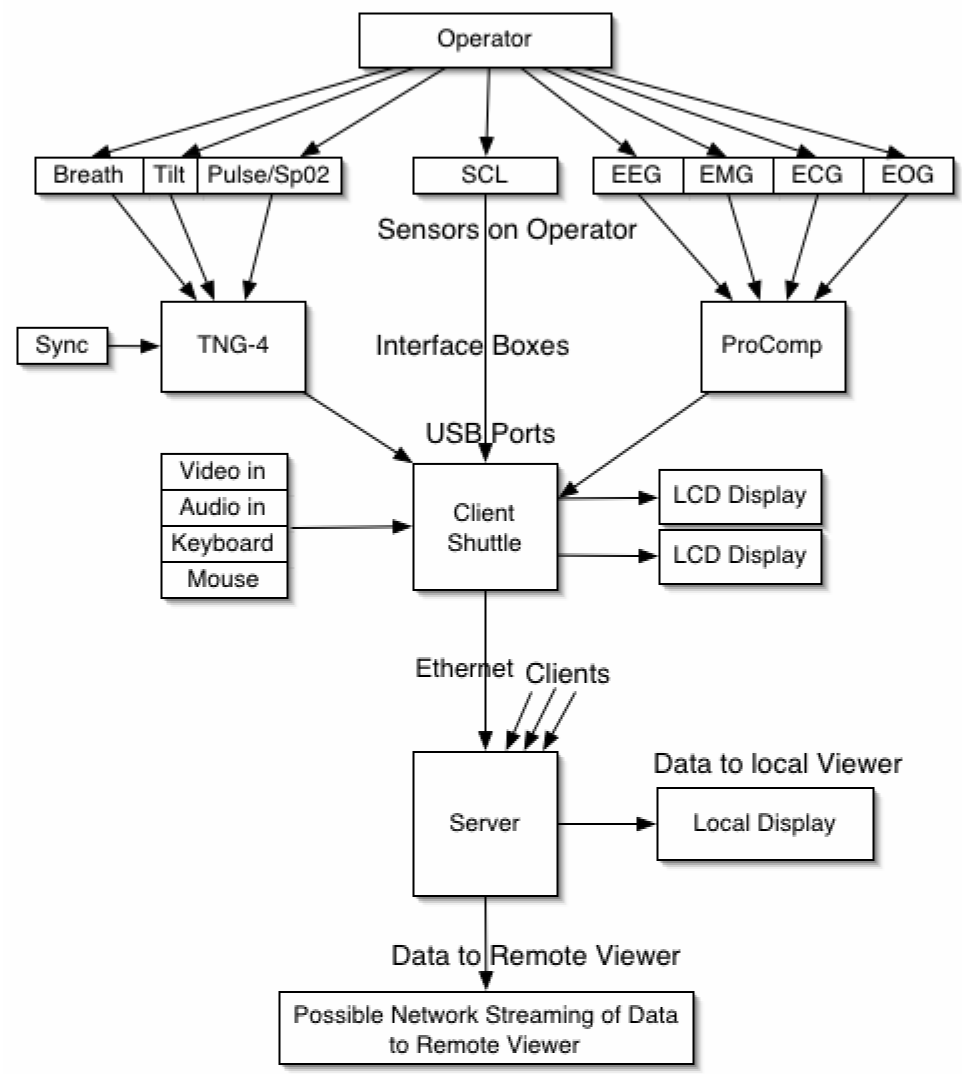
Wednesday, May 21, 2003



For each Pod PC, the Human Interface Peripherals include video and voice data acquisition, TNG-4 (respiration, blood-volume pulse, accelerometers, time-sync pulses), SCL (skin conductance level), and ProComp (bioelectric signal interface: EMG, ECG, EEG)



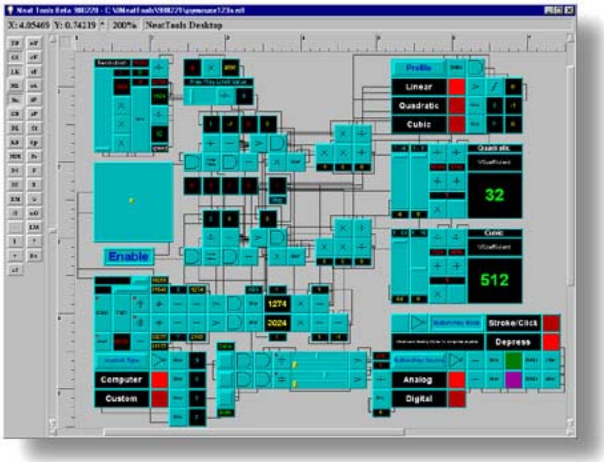
This schematic details the interface system components for each of the four users of the Quad Pod.



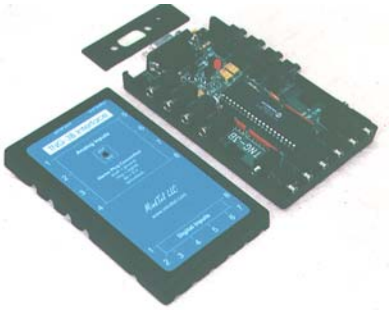
Data flow representation for each Quad Pod user.

Appendix 3. NeatTools Software and TNG Interfaces

Since the mid 1990s, our team, under leadership of Dave Warner, has been developing a modular suite of hardware and software technologies for human-computer interfacing,. The flagship of this system is a sophisticated visual-programming and runtime environment known as NeatTools, available for free download from www.pulsar.org. Unlike textual programming languages, NeatTools applications are developed by dragging, dropping, and interconnecting modules (visual icons) on the NeatTools desktop. Modules typically have a number of properties that can be modified by right clicking on the module and then adjusting parameters and other fields. Because NeatTools is multithreaded, the programmer can develop and edit an application, even while it is running and displaying data in real time. NeatTools is extensible, in that new modules can be written in C++ and loaded optionally at runtime as dynamic link libraries (DLLs). A program generator to facilitate the writing of external modules is available at www.pulsar.org, as are documentation and representative application programs.



Our hardware is based on TNG serial interface boxes (palm sized) that allow signals from sensors and transducers to be interfaced to PCs, using NeatTools or other environments, such as LabView. At the heart of each TNG interface unit is a PIC microcontroller programmed in assembly language that handles most of the functions of the device; because they are flash memory devices, they can readily be reprogrammed as needed. TNG-3B accepts signals from 8 analog and 8 digital sensors, and streams the data at 19.2 kbps. NeatTools includes a TNG3 module to accept and distribute the signals. Standard sensors, mounted on cables with stereo or mono plugs, include photocells, bend and pressure sensors, rotary and slide potentiometers, and tactile switches. For use with TNG-3B or TNG-4, we also have a 2-axis MEMS accelerometer/tilt-sensor. TNG-3B has been tested to be compliant with FCC regulations.



TNG-4 is a serial interface with 8 analog inputs, 4 analog outputs, and 16 bidirectional digital lines. In addition, TNG-4 is extensible via its SPI port (Motorola's Serial Peripheral Interface that employs a synchronous serial protocol). Among the SPI extension boards developed to date are servo motor control (each board can control 8 servos and up to 8 boards can be daisy-chained); LCD display; keypad input (up to 8 × 8) and IR communication; vibrotactile control (up to 8 vibrator motors per board, which can be used for other pulse-width-modulation applications too); AC

and/or DC relay control (4 per board; mix and match); temperature sensing (thermistor or thermocouple). There is also an electromyography (EMG) board that connects to an analog input of TNG-4 and displays rms values of raw EMG signals.

There are two distinct versions of TNG-4: streaming mode (like TNG-3B, but now duplex) and command mode; they differ only in the program in the respective PIC chip. In command mode, the computer issues specific byte sequences instructing the device how to configure itself and what specific data to accept or return. By repetitive issuance of such commands, the device can be made to stream in effect. NeatTools at present has a TNG4 module for the streaming mode version of TNG-4 only; but it is easy to construct simple data flow networks to produce the required byte command sequences for specific applications. In due course, we will develop a command mode module for TNG-4. Command mode TNG-4 is well suited to work with handhelds such as Palm OS and Pocket PC devices. We already have working interface programs on both platforms. An interface program for the TI-83 graphical calculator is under development.

An extended technical description of these technologies is available at
http://qube1.mindtel.com/~edlipson/CoreTech.pdf.

For more information (and downloads) on NeatTools, visit
www.pulsar.org,
specifically
http://www.pulsar.org/2k/neattools/.

For TNG-3B, see http://www.mindtel.com/mindtel/anywear.html.

For TNG-4, see
http://qube1.mindtel.com/~edlipson/TNG/TNG-4/TNG4.pdf
and for SPI extension boards, visit
http://www.sensyr.com/manuals/.

Archival information on TNG-4 (streaming version) is at
http://www.pulsar.org/archive/ed/tng/TNG-4/
and
http://www.pulsar.org/archive/ed/tng/TNG-4/.

Appendix 4. Description of Customized Devices.

The Pod Detail diagram (Appendix 2) depicts some devices that will be customized for the Quad Pod project. This appendix serves to offer a general description of these customizations.

Turbocharged TNG-4

A standard TNG-4 data acquisition device uses a PIC16F74 processor running at 4 MHz and communicates at 19.2 kbps. By increasing the processor clock speed to 12 MHz, we can increase the communications bit rate to 57.6 kbps. By utilizing either a PIC16F874 or a PIC16C774 processor we can increase the ADC bit resolution from 8 bits to 10 and 12 bits, respectively.

The increased ADC resolution comes at the price of having to transmit more data per acquisition cycle. At 57.6 kbps, 360 data packets (samples) per second can be transmitted when using ADC resolutions in excess of 8 bits. The standard 8-bit resolution protocol would allow 480 data packets (samples) per second at 57.6 kbps.

Time Sync Pattern Box

One of the difficulties of simultaneous data acquisition on four separate computers is maintaining sub-second synchronization of the data. As long as the four computers of the Quad Pod are colocated, a simple solution is to use a common signal source as part of the data stream.

The Time Sync Pattern Box is a rededicated command-mode TNG-4 connected via USB to one of the Quad Pod computers. Modified firmware will automatically generate a pulse width modulated digital signal on each of the 4 TNG-4 digital I/O port connectors immediately after initialization on power-up. Each Pod TNG-4 will be connected to one of the four digital output ports on the Time Sync unit. Using the separate ports will facilitate connectivity. The unit will be battery powered to maintain the electrical isolation of the human interfaces.

Using a slightly modified TNG-4 would allow acquisition of currently unspecified common parameters if the need arose. Room temperature is an example of such a parameter.

As the top TNG-4 sample rate is anticipated to be 360 samples per second, the shortest pulse width should be about 5.5 milliseconds (ms): two sample periods. The Time Sync Pattern Box will generate a positive-going leading edge every 0.1 second. The duration of the positive phase of the timing pulse increments 5.55 ms every 0.1 second from 5.55 ms to 88.9 ms in 16 steps.

Respiration Amplifier

The UFI Pneumotrace II respiratory band output is in the range -100 to +400 mV. The output signal can only drive input impedances in excess of 100 kΩ (> 1 MΩ preferred). The Pneumotrace output signal is also AC-coupled with a time-constant in excess of 20 seconds.

Optimally, two respiration bands should be used: one at the level of the navel and the other around the upper chest.

The Respiration Amplifier for the Quad Pod project will provide gain and filtering for up to two Pneumotrace respiratory bands and connectivity to TNG-4. The device will be powered by TNG-4. The device will have a frequency response of approximately 0.05 to 2 Hz. There is no electrical connection to the subject.

IR Plethysmograph Signal Amplifier

This device will allow use of the Nonin SpO_2 sensors with TNG-4. The device will power the sensor and all TNG-4 to capture the blood volume pulse signal with appropriate amplification and filtering. There is no direct electrical connection to the subject with this apparatus.

If SpO_2 is desired, the sensor can alternatively be attached to a standard XPOD module equipped with a serial-to-USB converter.

SCL (skin conductance level) Device

This device will continuously digitize the subject's SCL (skin conductance level) with at least 10 bits of resolution over a range of 0 to 100 micromhos (microsiemens). The device can be calibrated by commands from the host to switch in 0.1% precision resistors. Other features include a 12-bit DAC for zero suppression and a device to read ambient temperature (optional).

The data rate (not baud rate) can be controlled over a limited range from the host. The default rate is 100 samples per second.

The SCL device is powered by a 9V alkaline battery. The device power is enabled by the assertion of DTR from the host interface (just like TNG-4). The battery-powered side of the serial interface is optically isolated from the host.

To measure SCL, a constant 0.5 volt potential is applied to the subject by means of a pair of electrodes. Even so, the device presents much less of a hazard than a 9V alkaline battery.

Appendix 5. ProComp Infiniti Product Description

Source: http://www.thoughttechnology.com/procomp.htm

ProComp Infiniti™	
Product Information	The ProComp Infiniti is a new eight-channel, multi-modality encoder that has all the power and flexibility you need for real-time, computerized biofeedback and data acquisition in any clinical setting. The first two sensor channels provide ultimate signal fidelity (2048 samples per second) for viewing RAW EEG, EMG and EKG signals. The remaining six channels (256 samples/sec) can be used with any combination of sensors, including EEG, EKG, RMS EMG, skin conductance, heart rate, blood volume pulse, respiration, goniometry, force, and voltage input. In short, the ProComp Infiniti covers the full range of objective physiological signals used in clinical observation and biofeedback. Housed in an ergonomically designed case and requiring only a USB port, ProComp Infiniti can be used with any IBM-compatible laptop or desktop PC. What's more, ProComp Infiniti can capture data in real time by connecting directly to the PC via fiber-optic cable, or it can store data on a Compact Flash memory card for uploading later to the PC. ProComp Infiniti comes complete with: - 14 bit resolution, eight-channel ProComp Infiniti encoder unit - TT-USB interface unit - Fiber-optic cables (1' and 15') - Four alkaline "AA" batteries - Sleek fabric storage and carrying case
Ordering Information	To order please call 1-800-361-3651 More information email prodlit@thoughttechnology.com

Appendix 6. Nonin Xpod Oximeter Specifications

(see following pages)

Nonin Xpod Patient Cable Oximeter, REV. 29+
SPECIFICATIONS

1.	Oxygen Saturation Range	0 to 100%
2.	Pulse Rate Range	18 to 300 pulses per minute
3.	Measurement Wavelengths	Red - 660 Nanometers Infrared - 910 Nanometers
4.	Accuracy	
	SpO_2	
	(± 1 Standard Deviation)♦	70 - 100% ± 2 digits for adults using the Finger Clip Sensor
		70 - 95% ± 3 digits for neonates using infant or neonatal sensors
		70 - 100% ± 3 digits for adults using Flex or Reflectance Sensors
		70 - 100% ± 4 digits using Ear Clip Sensor
		Below 70% is not specified for all sensors
	Rate Accuracy	± 3% ± 1 digit

♦ Standard Deviation is a statistical measure: up to 32% of the readings may fall outside these limits.

5.	Temperature	
	a) Operating	0° C to +50° C
	b) Non Operating	-20° C to +50° C
6.	Humidity	
	a) Operating	10 to 90% Non Condensing
	b) Non Operating	10 to 95% Non Condensing
7.	Power Draw	60 mW - typical operating
8.	Voltage Input	2 to 6 volts dc operating Note: Sensor is not isolated from input voltage
9.	Output Digital Signals	0 - 5 volts (nominally)
10.	Patient Isolation	Greater than 12 megohm
11.	Leakage Current	Not applicable
12.	Dimensions	2.1” x 0.8” x 0.6” (53 x 20 x 15mm)
13.	Weight	75g (including 6’ cable and connector)

14. Ruggedness immersion
    a) Shock — Per IEC 68-2-27
    b) Vibration — Mil-standard 810C, method 514-2

15. Sensors — Designed to use *Nonin* sensors only

INPUTS:

Red Wire = V+ (2-6VDC, 60mw typical)
Black Wire = Ground
Cable Shield = Ground
(Both Black wire and cable shield must be attached to ground on the host device)
Yellow Wire = ECG Sync (Optional)
Note: Sensor is not isolated from input voltage.

OUTPUTS:

Green Wire = Serial Output

FORMATTING OPTIONS:

ORDER #	MODEL #	SERIAL FORMAT #	WITH CONNECTOR
3873-001	3011	#1	No
3873-002	3012	#2	No
3873-101	3011	#1	Yes
3873-202	3012	#2	Yes

SERIAL DATA FORMAT #1:

1) Serial format — 9600, n, 8, 1
2) Rate — Send 3 bytes of data once a second.
3) Data

1st byte = **Status**

BIT 7 = **ALWAYS SET TO "1"**
BIT 6 = SENSOR DISCONNECTED, SET IF TRUE
BIT 5 = OUT OF TRACK, SET IF TRUE
BIT 4 = LOW PERFUSION, SET IF TRUE
BIT 3 = MARGINAL PERFUSION, SET IF TRUE
BIT 2 = BAD PULSE, SET IF TRUE
BIT 1 = HEART RATE BIT 8
BIT 0 = HEART RATE BIT 7

2nd byte = **Heart Rate** (511 = bad data) BIT "7" IS ALWAYS SET TO "0".
HEART RATE DATA = BITS 0 - 6
PLUS BITS 0 & 1 OF THE STATUS BYTE TO PROVIDE 9 BITS OF RESOLUTION.
3rd byte = **SpO2** (127 = bad data)

SERIAL DATA FORMAT #2:

1) Serial format — 9600, n, 8, 1

2) Rate Send 5 bytes of data 75 times a second.
3) Data
    a. HR value bits 7&8 (128-511), 511 = bad data 1 byte 3 times a second
    b. HR value bits 0-6 (0-127) 1 byte 3 times a second
    c. SpO2 value 0 - 100 1 byte 3 times a second
    d. Firmware revision level 1 byte 3 times a second
    e. Status byte 128 - 255 1 byte 75 times a second
        Bit 0 frame Sync, set for 1 of 25, clear for 2-25 of 25
        Bit 1 green perfusion, set if true only during pulse
        Bit 2 red perfusion, set if true only during pulse
        Bit 3 sensor alarm, set if true
        Bit 4 out of track, set if true
        Bit 5 bad pulse, set if true
        Bit 6 sensor disconnected, set if true
        Bit 7 always set
            Note: bits 1 & 2 are set for yellow perfusion.
    f. Plethysmographic pulse value 0 - 254 1 byte 75 times a second
    g. Sync character (01) 1 byte 75 times a second
    h. Checksum = byte 1 + byte 2 + byte 3 + byte 4 1 byte 75 times a second

Extended Averaging Data
    i. E-HR value bits 7&8 (128-511), 511 = bad data 1 byte 3 times a second
    j. E-HR value bits 0-6 (0-127) 1 byte 3 times a second
    k. E-SpO2 value 0 - 100 1 byte 3 times a second

Non-Slew Limited with Standard Averaging
    l. SpO2 Slew value 0 - 100, 127 = bad data 1 byte 3 times a second
Beat to Beat Value (No Averaging or Slew Limiting)
    m. SpO2 B-B value 0 - 100, 127 = bad data 1 byte 3 times a second
    1 byte 3 times a second

Display Data
SpO2-D Display Value with Standard Averaging
    n. 0-11, 127 = bad data 1 byte 3 times a second
E-SpO2-D Display Value with Extended Averaging
    o. 0-100, 127 = bad data 1 byte 3 times a second
HR-D-MSB Display Value with Standard Averaging
    p. HR Value bits 7&8, 511 = bad data 1 byte 3 times a second
HR-D-LSB Display Value with Standard Averaging
    q. HR Value bits 0-6 (0-127) 1 byte 3 times a second
E-HR-D-MSB Display Value with Extended Averaging
    r. HR Value bits 7&8, 511 = bad data 1 byte 3 times a second
E-HR-D-LSB Display Value with Extended Averaging
    s. HR Value bits 0-6 (0-127) 1 byte 3 times a second

Data would be sent in the following format

Hz	BYTE					Hz	BYTE					Hz	BYTE				
1/75	1	2	3	4	5	1/75	1	2	3	4	5	1/75	1	2	3	4	5
1	01	STATUS	PLETH	HR MSB	CHK	26	01	STATUS	PLETH	HR MSB	CHK	51	01	STATUS	PLETH	HR MSB	CHK
2	01	STATUS	PLETH	HR LSB	CHK	27	01	STATUS	PLETH	HR LSB	CHK	52	01	STATUS	PLETH	HR LSB	CHK
3	01	STATUS	PLETH	SpO2	CHK	28	01	STATUS	PLETH	SpO2	CHK	53	01	STATUS	PLETH	SPO2	CHK
4	01	STATUS	PLETH	REV	CHK	29	01	STATUS	PLETH	REV	CHK	54	01	STATUS	PLETH	REV	CHK
5	01	STATUS	PLETH	*	CHK	30	01	STATUS	PLETH	*	CHK	55	01	STATUS	PLETH	*	CHK
6	01	STATUS	PLETH	*	CHK	31	01	STATUS	PLETH	*	CHK	56	01	STATUS	PLETH	*	CHK
7	01	STATUS	PLETH	*	CHK	32	01	STATUS	PLETH	*	CHK	57	01	STATUS	PLETH	*	CHK
8	01	STATUS	PLETH	*	CHK	33	01	STATUS	PLETH	*	CHK	58	01	STATUS	PLETH	*	CHK
9	01	STATUS	PLETH	***SpO2-D***	CHK	34	01	STATUS	PLETH	***SpO2-D***	CHK	59	01	STATUS	PLETH	***SpO2-D***	CHK
10	01	STATUS	PLETH	***SpO2 Slew***	CHK	35	01	STATUS	PLETH	***SpO2 Slew***	CHK	60	01	STATUS	PLETH	***SpO2 Slew***	CHK
11	01	STATUS	PLETH	***SpO2 B-B***	CHK	36	01	STATUS	PLETH	***SpO2 B-B***	CHK	61	01	STATUS	PLETH	***SpO2 B-B***	CHK
12	01	STATUS	PLETH	*	CHK	37	01	STATUS	PLETH	*	CHK	62	01	STATUS	PLETH	*	CHK
13	01	STATUS	PLETH	*	CHK	38	01	STATUS	PLETH	*	CHK	63	01	STATUS	PLETH	*	CHK
14	01	STATUS	PLETH	***E-HR MSB***	CHK	39	01	STATUS	PLETH	***E-HR MSB***	CHK	64	01	STATUS	PLETH	***E-HR MLSB***	CHK
15	01	STATUS	PLETH	***E-HR LSB***	CHK	40	01	STATUS	PLETH	***E-HR LSB***	CHK	65	01	STATUS	PLETH	***E-HR LSB***	CHK
16	01	STATUS	PLETH	***E-SpO2***	CHK	41	01	STATUS	PLETH	***E-SpO2***	CHK	66	01	STATUS	PLETH	***E-SpO2***	CHK
17	01	STATUS	PLETH	***E-SpO2-D***	CHK	42	01	STATUS	PLETH	***E-SpO2-D***	CHK	67	01	STATUS	PLETH	***E-SpO2-D***	CHK
18	01	STATUS	PLETH	*	CHK	43	01	STATUS	PLETH	*	CHK	68	01	STATUS	PLETH	*	CHK
19	01	STATUS	PLETH	*	CHK	44	01	STATUS	PLETH	*	CHK	69	01	STATUS	PLETH	*	CHK
20	01	STATUS	PLETH	***HR-D-MSB***	CHK	45	01	STATUS	PLETH	***HR-D-MSB***	CHK	70	01	STATUS	PLETH	***HR-D-MSB***	CHK
21	01	STATUS	PLETH	***HR-D-LSB***	CHK	46	01	STATUS	PLETH	***HR-D-LSB***	CHK	71	01	STATUS	PLETH	***HR-D-LSB***	CHK
22	01	STATUS	PLETH	***E-HR-D-MSB***	CHK	47	01	STATUS	PLETH	***E-HR-D-MSB***	CHK	72	01	STATUS	PLETH	***E-HR-D-MSB***	CHK
23	01	STATUS	PLETH	***E-HR-D-LSB***	CHK	48	01	STATUS	PLETH	***E-HR-D-LSB***	CHK	73	01	STATUS	PLETH	***E-HR-D-LSB***	CHK
24	01	STATUS	PLETH	*	CHK	49	01	STATUS	PLETH	*	CHK	74	01	STATUS	PLETH	*	CHK
25	01	STATUS	PLETH	*	CHK	50	01	STATUS	PLETH	*	CHK	75	01	STATUS	PLETH	*	CHK

* Undefined

Nonin P/N 2921-000
Rev D