FLEXIBLE NETWORK TRANSCEIVER
NEXT GENERATION TELEMETRY NETWORKING

K. D. Brown
NNSA -Kansas City Plant
Advanced Telemetry Engineering
EB9/BW31
2000 E 95th Street
Kansas City, MO 64131

John Klimek
JHU-APL
Sr. Electronics Engineer
Research & Technology Dev. Center
Laurel, MD 20723

ABSTRACT

This paper describes the Flexible Telemetry Transceiver (FNT)-a modular, scalable, standards-based, software configurable, microwave wireless telemetry network transceiver. The FNT enables flexible, high-rate, long-range, duplex, network services across multipoint to multipoint wireless channel.

KEYWORDS

Telemetry Network Transceiver, Flexible Network Transceiver, Flexible Physical Layer, Distributed Transmitter, DTX, Flexible Telemetry Receiver, FTR, Flexible Network Processor, FNP, Flexible Phased Array Antenna, FPAA.

INTRODUCTION

Flexible Network Transceiver System Description

The Flexible Wireless Network Transceiver (FNT) is a military robust, flexible, advanced, modular, scalable, standards based, software configurable, microwave transceiver that can transmit and receive data across a mobile wireless channel with other transceivers, collectively forming a multi-node distributed telemetry network. A transceiver system block diagram is shown in Figure 1. A telemetry network diagram is shown in Figure 2.

It has a Flexible Network Processor (FNP) comprising a layered network service stack, a medium access controller (MAC), and a physical layer interface (see Figure 2). The FNP enables wireless network communication between a networked station application and the wireless network channel. The FNT also includes a physical layer that is scalable in terms of frequency, data rates, RF power, and signal waveforms. The physical layer architecture includes phased array antenna technology, enabling beam forming and steering, resulting in management of wireless channel beam spatial characteristics.

A network service stack, MAC, and physical layer interface can be integrated into the FNP to form a network service software and hardware stack that serves to translate between the network and the baseband host application. The FNP also defines the protocols which enable the baseband host application to register, synchronize, and exchange data payloads within a collection of distributed wireless nodes in space, air, sea, or ground. Information assurance in terms of encryption, anti-intrusion, anti-jam, can be embedded within the flexible network processor enabling reliable, secure, wireless

connectivity between diverse assets. The compact size and scalable architecture of the FNT enables agile in-situ management of frequency, transmit range, S/N, modulation, bandwidth, data rate, and beam steering of transmit and received waveforms. General specifications are shown in Table 1.

The FNT is based upon a flexible telemetry transceiver physical layer. The physical layer components have been integrated into the network service stack through a customized 802.11 medium access controller (MAC). The physical layer is configured and data packets are transmitted and received through the MAC. The FNT physical layer (Phy Layer) comprises a flexible data transmitter, data receiver, and a phased array antenna.

The Distributed Transmitter (DTX) functions to modulate an S band carrier with input digital data stream and amplifies the power of this signal so that it can be transmitted across a wireless channel. The DTX is based on a modular baseband programmable signal processor, and microware signal processors. The baseband waveform processor can accommodate numerous modulation, wave shaping filters, signal synthesizers, etc., leading to a plethora of signal types. The modular frequency upconverter with a programmable carrier synthesizer enables operation in a range of frequency channels. The modular power amplifier driver with a programmable gain interface and modular output power stages enables a broad range of dynamic link margins. The DTX is patent pending technology that has been flight tested on ICBM applications on the Pacific Reagon Test Range. The phased array antenna with dynamic beam forming and steering enables a range of sweeping, tracking, or gain control capabilities. The DTX has not been miniaturized, but currently occupies approximately 10 cubic inches and weighs approximately 0.25 pounds.

The Flexible Telemetry Receiver (FTR) functions to amplify weak S band signals from a wireless channel and to frequency translate and demodulate the original data stream. The FTR is based on a modular programmable signal processor and microwave signal processors. The low noise amplifier and RF down converter sections are capable of variable filter and amplifier gains. The down conversion mixer is driven by a programmable carrier synthesizer, enabling operation in a range of frequency bands. A modular IF section enables a number of external and or internal demodulators and waveform digitizers. The modular baseband programmable signal processor is capable of digitizing, synchronizing, filtering, and extracting data bits from modulated IF signals. It reconstructs the original data stream with a synchronous clock. The FTR has not been miniaturized, but is targeted for approximately 10 Cu inches and weighs approximately 0.25 pounds.

The Phased Array Antenna (PAA) functions to transform the electrical signals from the transmitter into electromagnetic waves that can propagate across the wireless channel. In a similar manner it functions to transform weak electromagnetic waves that strike the antenna into electrical signals that the receiver can process. It is based on an array of microwave patch antennas, RF signal processing, beam steering networks, and digital control processors. The antenna can operate manually with open loop control for beam pointing or can operate automatically with closed loop control for tracking moving targets. The PAA occupies approximately 8”x22”x2” and weighs less than 3 pounds.

Physical engineering prototypes of the FNT subsystems are shown in Figure 2. A test bed will be assembled to initially demonstrate and investigate ad hoc behavior for an

independent basic service set. Future plans include investigation of more complex networking architectures as the FNT matures. Simple testbed functional blocks are shown for a single MAC node from JHU/APL and a multi-node network assembled to demonstrate network behavior such as carrier sense multiple access/collision avoidance that is common to 802.11 systems.

CONCLUSION

The FNT is under development at the NNSA's Kansas City Plant as part of the Advanced Telemetry Technology Development program and at JHU-APL as part of the Research and Technology Development program. KCP has supported design and development of weapons evaluation telemeter equipment for over 4 decades in conjunction with the DOE National Laboratories and JHU-APL has supported DoD technology development for over 4 decades. They are partnering to integrate microwave Phy Layer technology with custom MAC services. This technology enables telemetry networking services necessary for users of advanced wireless mobile data acquisition systems. The FNT is developed as part of an advanced telemetry networking testbed at the KCP and JHU to experiment with telemetry networking principles.

ACKNOWLEDGEMENTS

I would like to thank the engineering staff of the NNSA's Kansas City Plant-KCP Advanced Engineering Department for their investments in design development, system integration, and system testing. Particularly, Troy Kaeb, Dean Oliver, Chad Deconink, Rohit Parthasarathy, and Jeff Stepp. I would also like to thank NNSA-KCP NNSA's Kansas City Plant management for investment support and authorization to invest in the FNT program, namely Susan Pemberton and Dan Meservey. I would also like to thank the Johns Hopkins University Applied Physics Laboratory and the University of Kansas faculty and staff, for their leadership and expertise which made the FNT system come to life, primarily Dr. Bill D'Amico, John Klimek, Bob Bamberger, and Osama Farraq, Dr. Chris Allen, Dr. Glenn Prescott, and Dr. Presad Gogenini.

REFERENCES

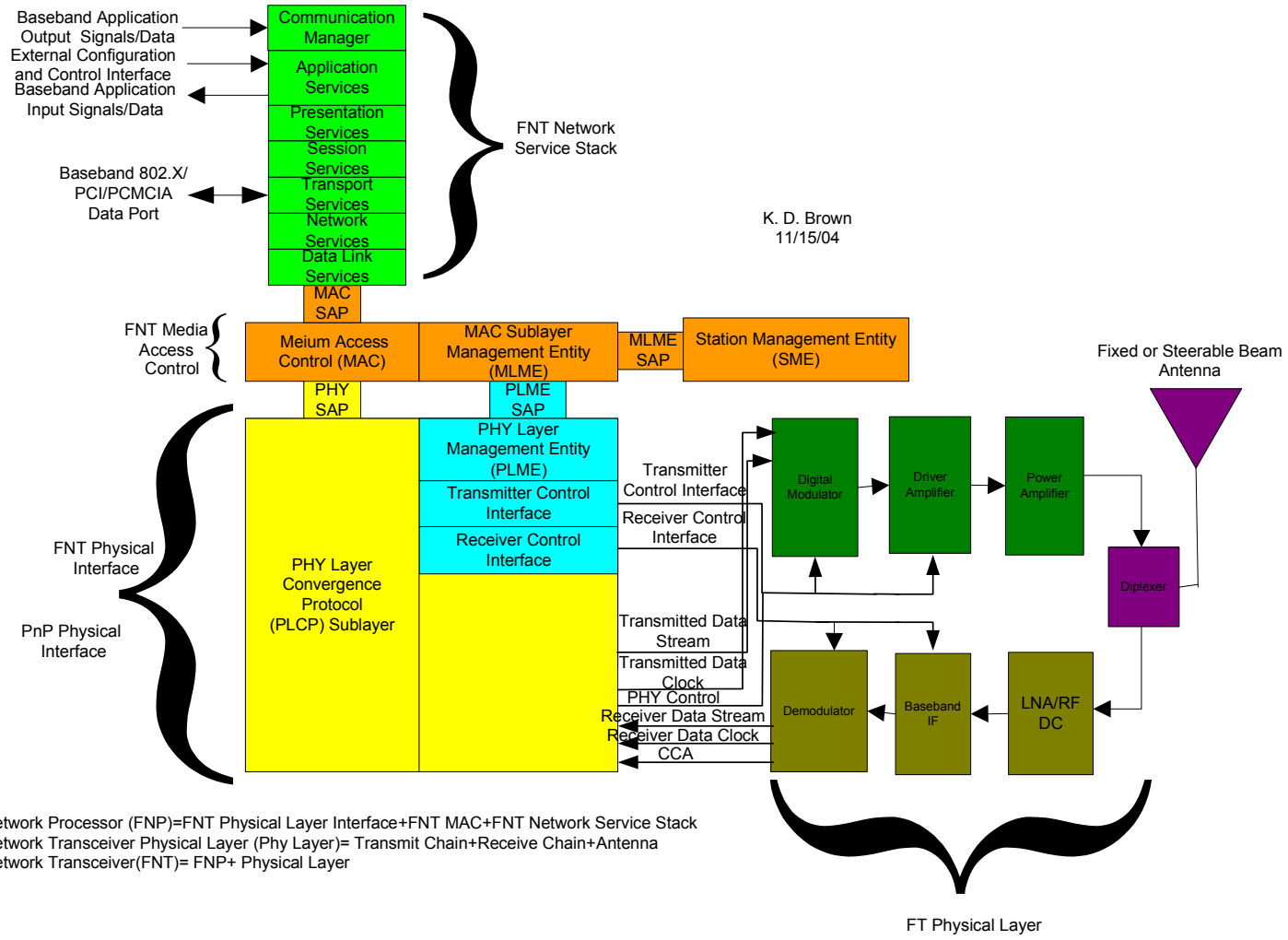
1. FNT Abstract; K. D. Brown, NNSA-KCP, 11/04.
2. High Altitude Transmitter Flight Testing; K. D. Brown, Dr. Trevor Sorensen; 2004 ITC Proceedings
3. Dynamic Tracking Phased Array Data Links; K. D. Brown, Dr. Chris Allen; 2004 ITC Proceedings.
4. PnP Transceiver; K. D. Brown; 2005 Responsive Space Conference Proceedings.

Table 1
Preliminary Specifications

Network Stack	
Network Services	802.11 with Enhancements
Transmit Chain	
Frequency	Sband-2200-2400 MHz Lband- 900 to 1900 MHz with minor changes C/X/K band options in development
Bandwidth	200 MHz
Max Output Power	10W
Gain Control	30 dB
Modulation	FSK., SOQPSK, (Multi-h CPM in development)
Data Rate	1-40 Mbps
Operating Power	typical 800 mA @ 5V, 900 mA @ 28V
Volume	1.9”x3”x.1.8”
Weight	~0.25 lbs.
Receiver Chain	
Frequency Range	Sband-2200-2400 MHz Lband- 900 to 1900 MHz with minor changes C/X/K band options in development
RF Bandwidth	200 MHz
Sensitivity	-74 dBm at 200 MHz BW -97 dBm at 1 MHz BW
IF Bandwidth	1- 40 MHz in 4+ ranges
Demodulation	FSK, SOQPSK (Multi-h CPM in development)
Data Rate	1-40 Mbps
Noise Figure	3-5 dB
Dynamic Range	80-90 dB
Operating Power	estimated 1000 ma @ 5V
Volume	estimated 1.9”x3”x1.8”
Weight	~0.25 lbs.
Phased Array Antenna	
Gain (Passive Element+Active)	65 dB
3 dB Beamwidth	10-40º
Steering Angle	+-60º
Operating power	1.5A @5V and 10ma @12V
Volume	estimated 8”x22”x2”
Mass	<3 lbs

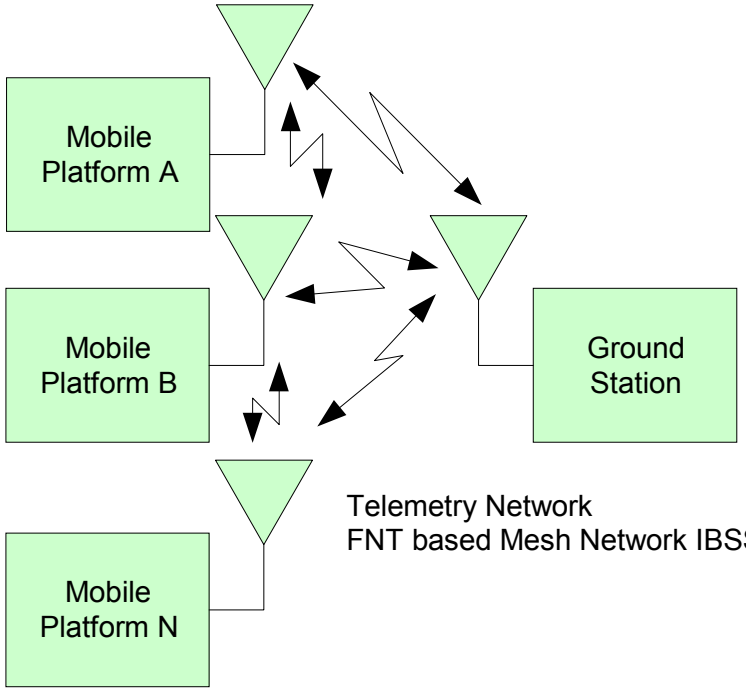
Figure 1

Flexible Network Transceiver Block Diagram

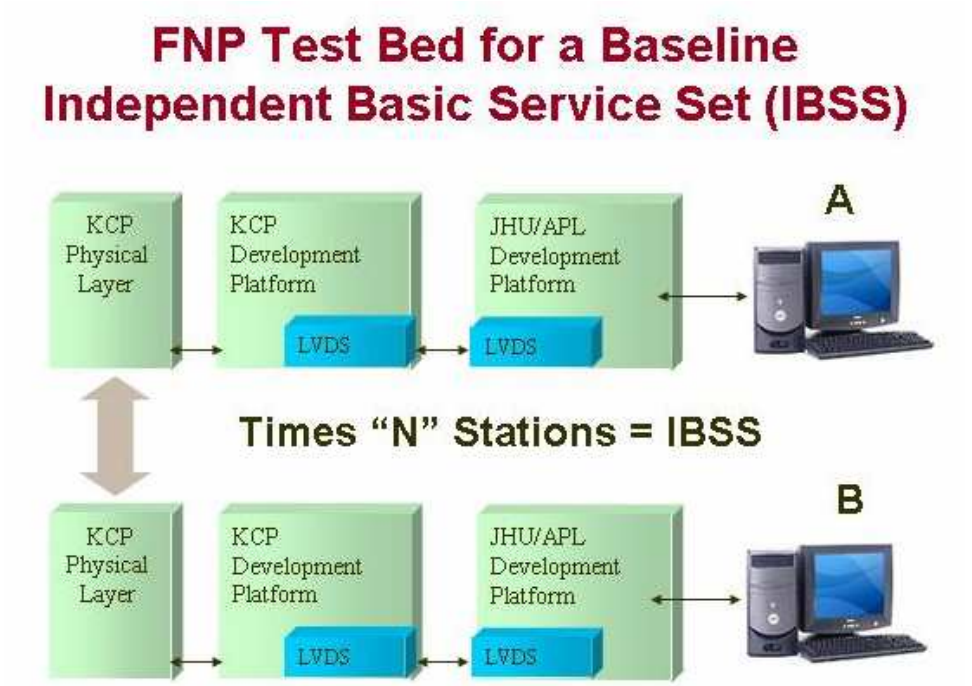


Flexible Network Processor (FNP)=FNT Physical Layer Interface+FNT MAC+FNT Network Service Stack
Flexible Network Transceiver Physical Layer (Phy Layer)= Transmit Chain+Receive Chain+Antenna
Flexible Network Transceiver(FNT)= FNP+ Physical Layer

Figure 2
FNT Telemetry Network Testbed



Telemetry Network
FNT based Mesh Network IBSS Links



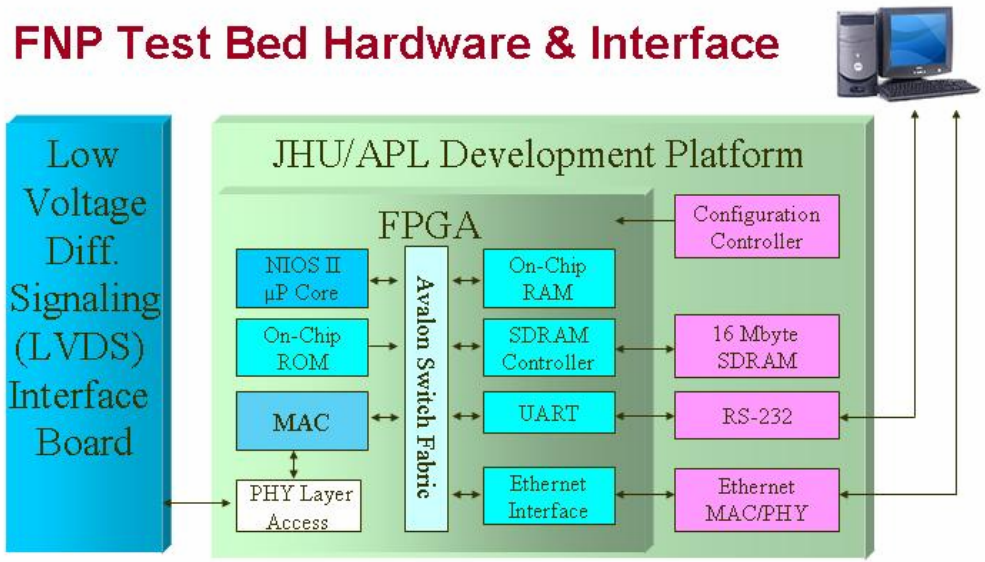
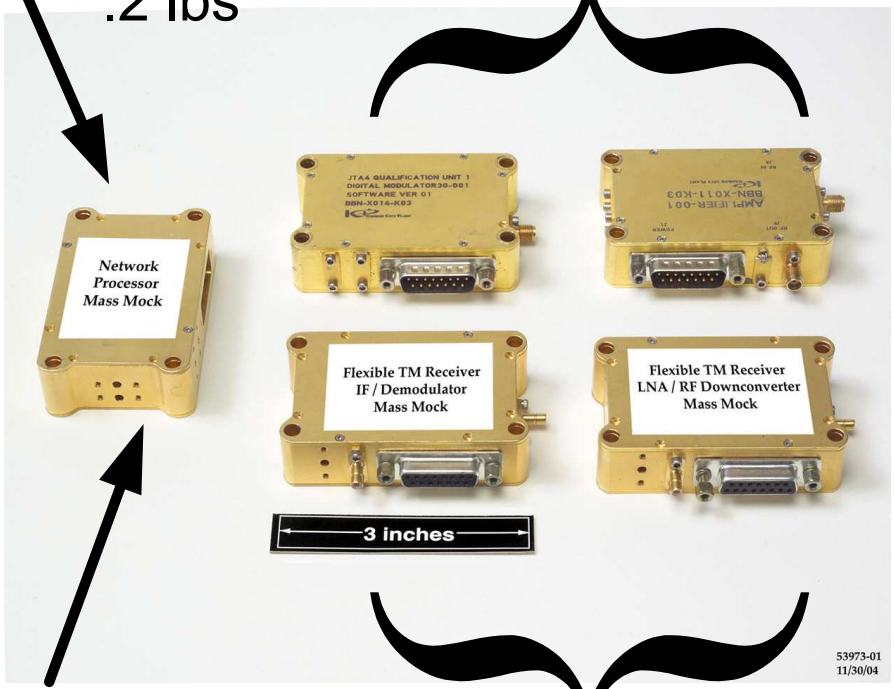


Figure 3
FNT Engineering Prototypes

Flexible Network Transceiver

1.9"x3"x.9"
.2 lbs

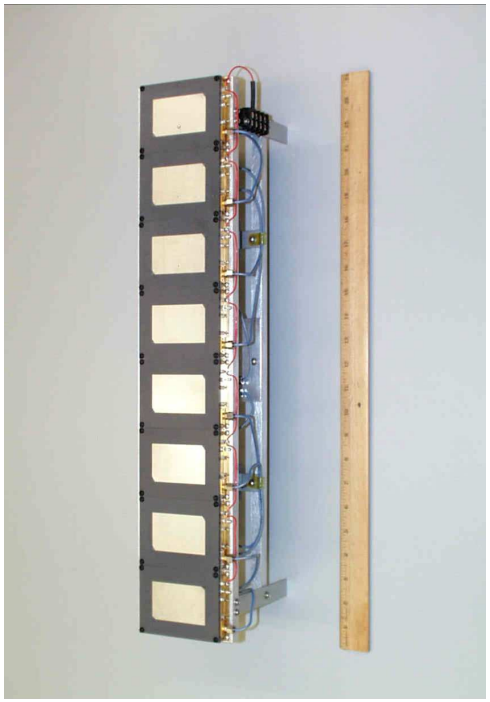
Transmit Chain



Network
Processor

Receive Chain

8"x22"x.2"
<3 lbs



Phased Array
Antenna