The Firehose CubeSat Radio

Michael Caffrey
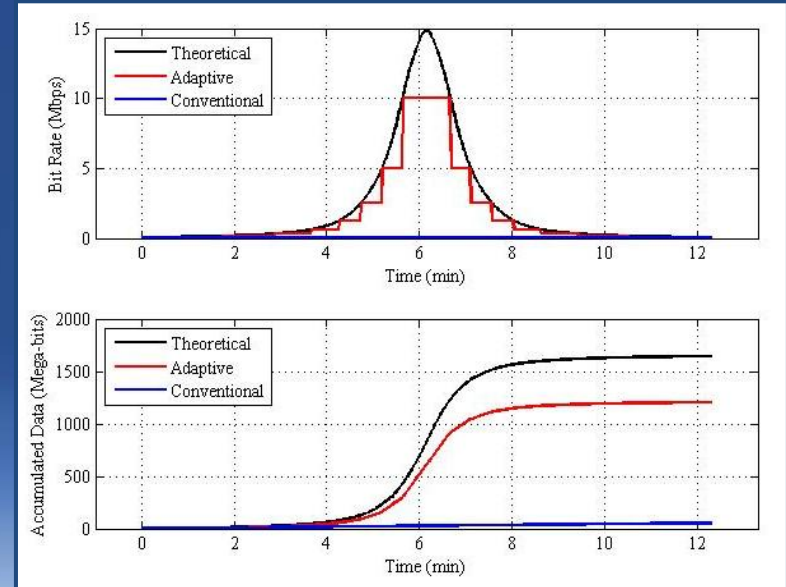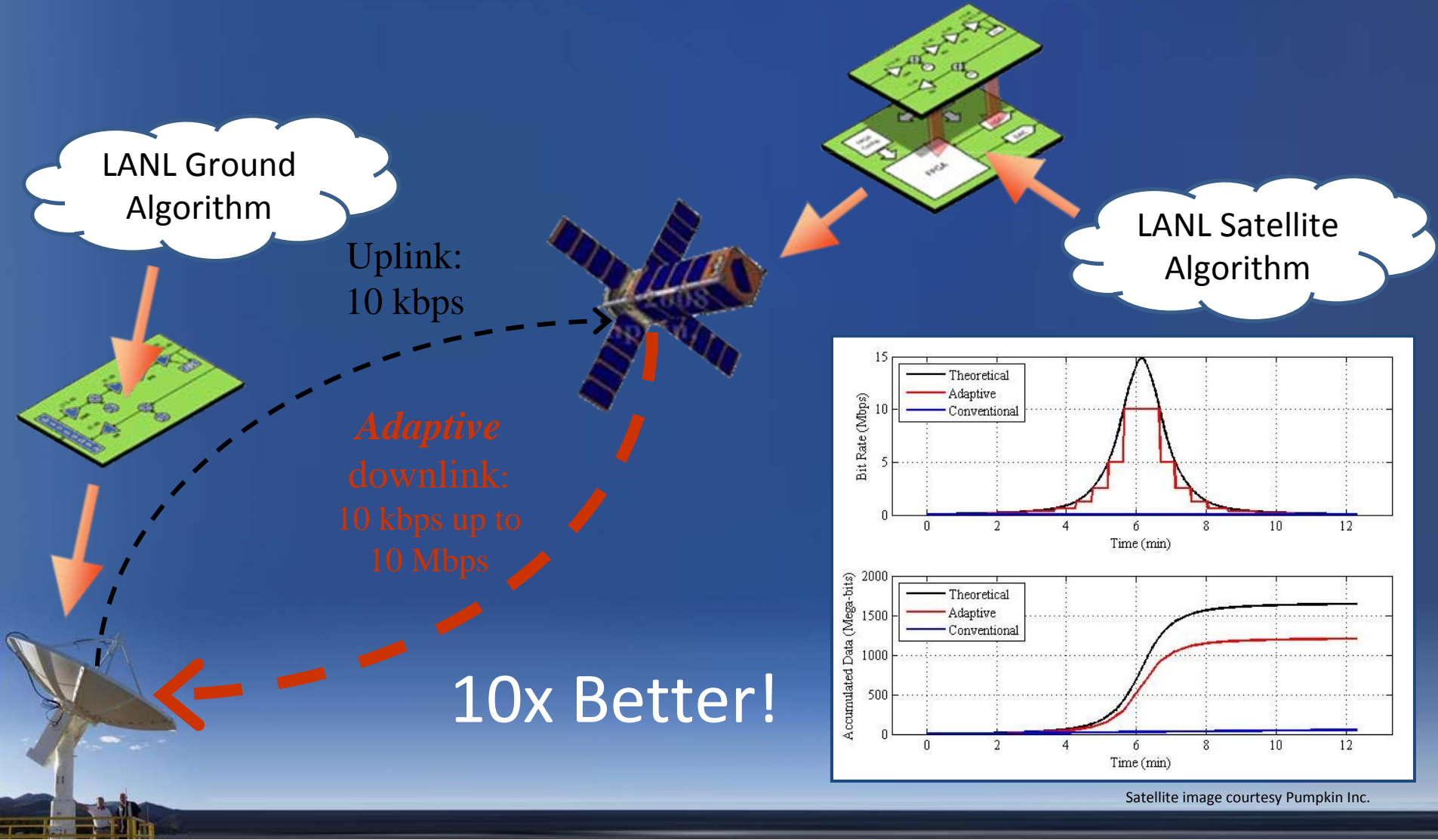
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The Firehose CubeSat Radio

LANL Ground Algorithm

LANL Satellite Algorithm

Uplink: 10 kbps

Adaptive downlink: 10 kbps up to 10 Mbps

10x Better!

Satellite image courtesy Pumpkin Inc.

Adaptive Radio Downlink: 10K-10Mbps Data

Channel Bandwidth Limit
•Range
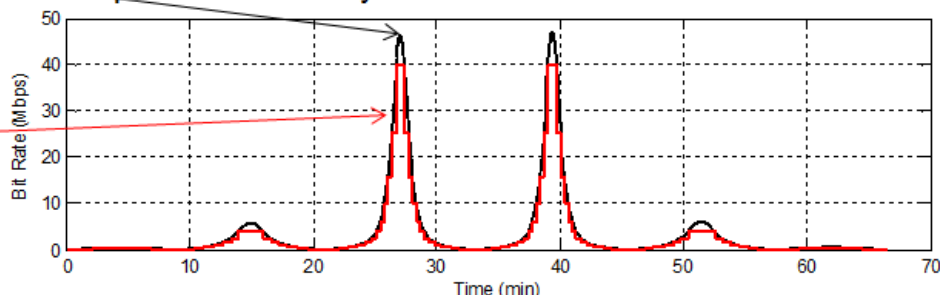•Noise Temperature
•Antenna Pattern Mismatch

Link Optimization
•Constant RF Power
•Finite number of bit rates
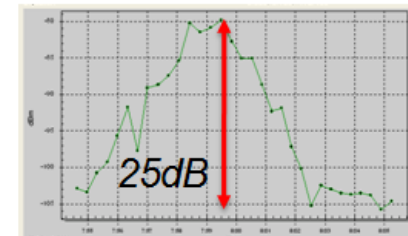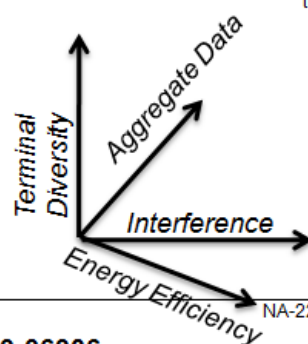•Peak output limited by
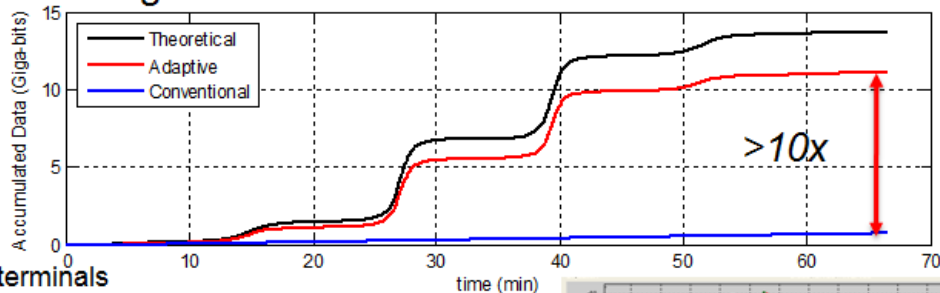 •*Computation*
  •*Bandwidth allocated*

Advantages
•CubeSat compatible
  •*~ 5W peak*
  • *PC104 card*
•*10x* more data
•Provides *ROBUST* communications
  •*Compensation for pointing errors*
  •*Commissioning operations*
•*Real-time* compatible with wide range of ground terminals
  •*Rate adapts to capabilities of ground station*
•Super energy efficient (1 – 2 orders of magnitude)
  •*Use of downlink during optimal channel conditions*
•Tolerant to interfering signals or jamming
•Adaptive communications are ubiquitous, this approach is unique in its range of *adaptability and efficiency*

Modeled Instantaneous Data Rate:
6 passes from a day in the life of CFE

Integrated Data Accumulated

Theoretical
Adaptive
Conventional

>10x

Aggregate Data

Terminal Diversity

Interference

Energy Efficiency

25dB

CFESat: RSSI > 80° pass

Los Alamos
NATIONAL LABORATORY
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NA-22: Office of Nonproliferation Research and Development

Features

Channel adaptive downlink

Power consumption ~5.5 W peak power

> Motherboard requires 3.3V
>
> RF requires 5.0V

2 GBytes of flash buffering

H-ARQ protocol (ARQ From flash only)

RF output power: ½ W

Frequencies

- 2.4GHz ISM downlink
- .9 GHz Amateur radio uplink

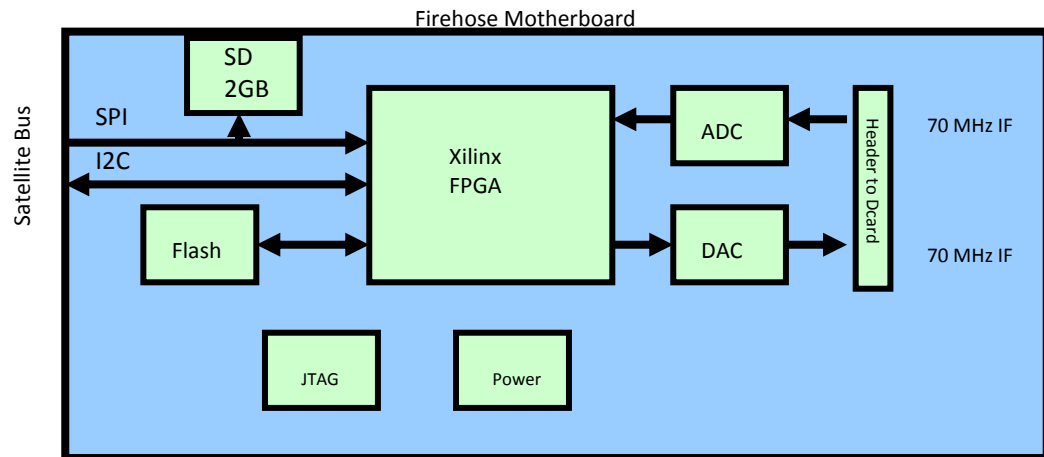50 Ohm SMA antenna interfaces

CSK compatible

SPI high speed

I2C for configuration, RX, priority down

9 Physical telemetry points, 12 state values

Simple '2 FIFO down 1 FIFO up' binary user protocal

True SDR: support for multiple waveforms, beacons, user designs, etc.

Firehose Motherboard

Satellite Bus
SPI
I2C
SD 2GB
Xilinx FPGA
ADC
DAC
Flash
Header to Dcard
JTAG
Power
70 MHz IF
70 MHz IF

Concept of operations:

1. Payload streams data into the SD flash
2. During contact, SDR masters flash and reads at variable rate
3. SD flash also provides ARQ buffer