tutes the bit-to-symbol/symbol-to-bit operations like a tree that forms a portion of a Fast-Fourier-Transform (FFT). Much like an FFT, the parallel computation may be structured in order to reduce repeated computations. Symmetry in the values was noted and allowed for the reduction of the bit-to-symbol mapping by a factor of 2.

This method computes bit-to-symbol likelihood mappings for a soft-in/soft-out decoder that operates over M-ary symbols, but receives and transmits bit-log likelihoods. There are two bit-to-symbol mappings. The first requires $M - 2$ operations and $\log_2 M - 1$ clock cycles. The second requires $O(M \log_2 M)$ operations and $\log_2 \log_2 M$ clock cycles. The symbol-to-bit mapping requires $\log_2 M$ clock cycles and $3M - \log_2 M - 4$ operations. In a pipelined architecture, the reduced operation counts also translate into reduced memory requirement.

This technology can apply to communications channels that use high-order constellations and decode over symbols from that constellation. This would potentially include a large number of communications channels, such as cable modems, disk drives, etc., as well as being a direct improvement to the Optical Communications End-to-End Test-bed, which is currently in use to demonstrate, test, and develop deep-space optical communications technology.

**Capacity Maximizing Constellations**

*Locations and bit labels of constellation points are optimized jointly.*

*NASA's Jet Propulsion Laboratory, Pasadena, California*

![Diagram showing gaps between parallel decoding capacity and Gaussian capacity](https://ntrs.nasa.gov/search.jsp?R=20100012796)

Gaps between parallel decoding capacity and Gaussian capacity [quantified as equivalent signal-to-noise-ratio (SNR) gaps] were computed for optimized and traditional PAM 2-, 4-, 8-, 16-, and 32-point constellations.

This work was done by Bruce E. Moision of Caltech and Michael A. Nakashima of Skillstorm, Incorporated for NASA’s Jet Propulsion Laboratory.

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ing to the proposal are unequal. Unlike in traditional constellations, both the locations of the points and the bit labels of the points are optimized jointly. In the optimization process, they are chosen to maximize either the joint capacity or the parallel decoding capacity at a target user data rate. Through numerical capacity computations, it has been shown that except in special cases, no constellations are universally optimal for all code rates and that the optimization of a constellation must target a specific code rate.

The proposed constellations have been used in a bit-interleaved coded modulation system employing state-of-the-art LDPC codes. In computational simulations, these constellations were shown to afford performance gains over traditional constellations as predicted by the gap between the parallel decoding capacity of the constellations and the Gaussian capacity (see figure).

This work was done by Maged Barsoum and Christopher Jones of Caltech for NASA’s Jet Propulsion Laboratory.