

1077-55-2262

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We generalize the classical max-flow, min-cut theorem from the setting of additive real-valued quantities (e.g. fluid volume, bits of information, traffic counts) flowing over directed graphs (e.g. pipelines, multicast networks having a single source, roadways) to more general information flowing over more general directed spaces (e.g. spacetimes, state spaces). In the process, we recast constraints on the capacities of communication channels as sheaves, flows as elements of a singular sheaf homology for directed spaces, and cuts as certain open neighborhoods of directed spaces satisfying a relative homological condition. We then discuss applications of our generalized duality theorem to various problems in network theory. (Received September 21, 2011)