Amorphous Computing Systems[1]

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Under various disguise, the idea of amorphous computing systems has initially emerged in the sci-fi literature, cf. the 1957 novel "*The Black Cloud*" written by the astrophysicist Sir Fred Hoyle; or the 1999 Hugo Award novel "*A Deepness in the Sky*" by the mathematician and computer scientist Vernor Vinge where the advanced amorphous computing systems appear in the form of "localizers". The contemporary engineering efforts for constructing such systems are represented, e.g., by the 2001 project of a "smart dust" by K.S J. Pister (University of California). Real bacteria represent an example of such systems in nature. From a computational viewpoint, the amorphous computing systems differ from the classical ones almost in every aspect: they consist of a set of simple processors or robots that can communicate wirelessly to a limited distance. The processors are randomly placed in a closed area or volume; in some applications they can move, either actively, or passively (e.g., in a bloodstream). All processors are equal; they do not share global clock and do not have unique identifiers. How can such systems compute? Do such systems possess universal computing power? Do finite automata suit such task? We present a generic model of such systems. The processors are modeled by timed probabilistic finite-state automata. In a "macro-sized" model, the automata communicate by a single-channel radio; in a "nano-sized" model, by molecular communication. We sketch the main ideas leading to the design of probabilistic communication protocols and to the emergence of communication networks and indicate some open problems. Although families of all resulting systems possess universal computing power it is not clear whether some of them can be simulated by a single universal machine.

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