2.1 Dynamical Regimes

RBNs have three dynamical regimes: *ordered*, *chaotic*, and *critical* [53, 16]. Typical dynamics of the three regimes can be seen in Figure 3. The ordered regime is characterized by little change, i.e. most nodes are static. The chaotic regime is characterized by large changes, i.e. most nodes are changing. This implies that RBNs in the ordered regime are robust to perturbations (of states, of connectivity, of node functionality). Since most nodes do not change, damage has a low probability of spreading through the network. On the contrary, RBNs in the chaotic regime are very fragile: since most nodes are changing, damage spreads easily, creating large avalanches that spread through the network. The critical regime balances the ordered and chaotic properties: the network is robust to damage, but it it not static. This balance has led people to argue that life and computation should be within or near the critical regime [30, 26, 9, 27]. In the ordered regime, there is robustness, but no possibility for dynamics, computation, and exploration of new configurations, i.e. evolution. In the chaotic regime, exploration is possible, but the configurations found are fragile, i.e. it is difficult to reach persisting patterns (memory). There is recent evidence that real GRNs are in or near the critical regime [5].

It has been found that the regimes of RBNs depend on several parameters and properties [19]. Still, two of the most salient parameters are the connectivity K and the probability p that there is a one on the last column of lookup tables. When $p = 0.5$ there is no probability bias. For $p = 0.5$, the ordered regime is found when $K < 2$, the chaotic regime when $K > 2$, and the critical regime when $K = 2$ [12]. The ordered and chaotic regimes are found in distinct phases, while the critical regime is found on the phase transition. Derrida and Pomeau found analytically the critical connectivity K_c[1]:

$$\langle K_c \rangle = \frac{1}{2p(1-p)} \tag{1}$$

This can be explained using the simple method of Luque and Solé [32]: Focussing on a single node i, the probability that a damage to it will percolate through the network can be calculated.

[1]This result is for infinite-sized networks. In practice, for finite-sized networks, the precise criticality point may be slightly shifted.