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New findings on the topology of tree networks: inevitable self-similarity and diverse hierarchical density

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Self-similar topology, which can be characterized as power law size distribution, has been found in diverse tree networks ranging from river networks to taxonomic trees. In this study, we find that the statistical self-similar topology is an inevitable consequence of any full binary tree organization. We show this by coding a binary tree as a unique bifurcation string. This coding scheme allows us to investigate trees over the realm from deterministic to entirely random trees. To obtain partial random trees, partial random perturbation is added to the deterministic trees by an operator similar to that used in genetic algorithms. Our analysis shows that the hierarchical density of binary trees is more diverse than has been described in earlier studies. We find that the connectivity structure of river networks is far from strict self-similar trees. On the other hand, organization of some social networks is close to deterministic supercritical trees.