Highly stretchable and self-healable supramolecular elastomers are potential requisites for skin electronics. Their desirable capabilities are due to dynamic cross-linking bonds that can be easily broken and re-formed. However, the underlying self-healing mechanisms of these elastomers as a result of their molecular structure remain elusive. Using coarse-grained molecular dynamics, we predicted the strain-induced damage of elastomers by bond-breaking and the self-healing of elastomers by bond-reforming. By performing network analysis on the microstructure of elastomers, we found that the damage and self-healing of elastomer are controlled by a key topological feature, i.e., the shortest paths between distant dynamic bonds. The straightness of shortest paths evolves with both strain and bond dynamics; it leads to a simple analytic model with an explicit microstructure-property relationship. This relationship serves as a basis for understanding the existing self-healable elastomers and a guide for the design of new ones.