distance between any two anchors of the network is necessarily known. Let us denote the set of edges joining two vertices which correspond to anchor nodes by $D_A$, which is a subset of $D$. Then the equations which apply to the framework after using the anchor node information include distance information and coordinate information and are of the form

$$\|p(i) - p(j)\|^2 = d_{ij}^2, \forall \{i, j\} \in D \setminus D_A,$$  \hfill (3)

$$p(i) = \bar{p}(i), \forall i \in V_A.$$  \hfill (4)

Determining a set of values $\bar{p}(i)$ for all $i \in V_D$ satisfying these equations is the localization problem. We note that the equations are written with the squares to have polynomial equations in the variables. Suppose that each squared distance $d_{ij}^2$ in (3) is replaced by $d_{ij}^2 + n_{ij}$, the quantity $n_{ij}$ being a (typically small) error in the squared distance (rather than in the distance itself); thus $d_{ij}$ remains the actual distance, and $n_{ij}$ constitutes the measurement noise effect. Then it is natural to consider the following set:

$$\|p(i) - p(j)\|^2 = d_{ij}^2 + n_{ij}, \forall \{i, j\} \in D \setminus D_A,$$  \hfill (5)

$$p(i) = \bar{p}(i), \forall i \in V_A.$$  \hfill (6)

This equation set is still overdetermined but will have no solution in general. One example of this problem involves localizing a single sensor node given noisy measurements of its distance from three anchors, as treated in [49]. In that case, there are two unknown coordinates of the single sensor node to be localized. But there are three equations perturbed by noise, and there is generically no solution. Given the graphical conditions that would guarantee unique localizability in the noiseless case, localization in the noisy case can be posed as a

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**Fig. 9.** The additional links that need to be inserted to create $G^2$ from $G$ are shown in this figure.