We present a non-parametric methodology, the symmetric thermal optimal path (TOPS) method to determine the dynamical time evolution of the lead-lag relationship between two stochastic time series. The method includes constructing a distance matrix based on the matching of all sample pairs between two target time series, and searching lead-lag relationship by minimizing the total mismatch. The searching process as obtaining the optimal path in the distance matrix landscape alleviates some inconsistencies by imposing that the lead-lag structure should be invariant when considering a time reversal of the time series. This symmetric thermal optimal path containing the time reversal would be more efficient to detect the real-time lead-lag structure. We use simulation to demonstrate the efficiency of the TOPS method in detecting dynamic time evolution of lead-lag relationship with allowance of multi-stage lead-lag structure. Furthermore, the performance of lead-lag relationship is also checked by bring in real analysis on high frequency data of U.S. stock market from Wharton Research Data Services (WRDS).