Shock-capturing and broad-bandwidth scale resolutions are two main challenges of compressible turbulent flow simulation. To meet the rigorous requests, a novel fifth-order hybrid scheme based on a uniform hybrid framework is designed. With the help of a continuous weight operator, the new scheme combines an upwind compact scheme for smooth regions and a compact-reconstruction weighted essentially non-oscillatory scheme for discontinuous regions. Numerical analyses and canonical numerical tests confirm that the new scheme has high accuracy, spectral-like resolution property and shock-capturing capability. Besides, the new scheme shows high computational efficiency compared to the related shock-capturing schemes and hybrid ones.