This paper proposes a tractable and scalable algorithm to identify and analyze bifurcation points of a large-scale power system model, which are directly related to dynamic voltage instability problems. Different types of bifurcations are analyzed, including: saddle-node (fold), Hopf, singularity-induced and limit-induced. An algorithm that combines optimization and predictor-corrector procedure is proposed for equilibrium tracing. The algorithm is based on calculation of only critical (rightmost and closest-to-zero) eigenvalues. The proposed algorithm is extended to the case of dynamic voltage stability assessment for power systems with optimized topology (simultaneously subjected to the topology control changes and generation re-dispatch). The proposed approach is illustrated on two (medium- and large-scale real-world) test power systems.