Framing is important for specification and verification of object-oriented programs. This dissertation develops the local reasoning approach for framing in the presence of data structures with unrestricted sharing and subtyping. It can verify shared data structures specified in a concise way by unifying fine-grained region logic and separation logic. Then the fine-grained region logic is extended to reason about subtyping.

First, fine-grained region logic is adapted from region logic to express regions at the granularity of individual fields. Conditional region expressions are introduced; not only does this allow one to specify more precise frame conditions, it also has the ability to express footprints of separation logic assertions.

Second, fine-grained region logic is generalized to a new logic called unified fine-grained region logic by allowing the logic to restrict the heap in which a program runs. This feature allows one to express specifications in separation logic.

Third, both fine-grained region logic and separation logic can be encoded to unified fine-grained region logic. This result allows the proof system to reason about programs specified in both styles.

Finally, fine-grained region logic is extended to reason about a programming language that is similar to Java. To reason about inheritance locally, a frame condition for behavioral subtyping is defined and proved sound.