# Efficient Checkpointing for Mobile Grid Computing Systems

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## Abstract

Checkpointing is the process of periodically saving intermediated data and machine states on reliable storage during the course of a long running application, so that in the event of a failure, the application can be recovered from the checkpoint saved prior to the failure, instead of starting the application from the beginning. In mobile grid computing systems, hosts are interconnected wirelessly and move at will. As a result, checkpointing becomes more complicated in a mobile grid computing system than in its conventional distributed computing counterpart, where hosts are stationary and interconnected by (broadband and fairly reliable) wire-lines.

Our research pursues checkpointing for mobile grid computing systems, an area with limited research so far. In such a system, link and node failures (due to transmission contention and modal moves) are more frequent, so even an application of relatively short execution duration calls for checkpointing. If a node in the system, say A, sends its data (namely, checkpoint information) to another node, say B, it is symbolized by A➔B, where A is the checkpoint consumer and B is the checkpoint provider. For a given system, each node would be a provider of checkpointing for **one** node and a checkpointing consumer of another node. Obviously, there are many ways to assign checkpointing consumers and providers, referred to as *checkpointing arrangements*. In general, a checkpoint arrangement is specified by $\{A_i \rightarrow B_i \mid A_i \neq B_i, U_{\text{for all } i} \{A_i\} = U_{\text{for all } i} \{B_i\} =$ set of system nodes$\}$.

The premise of our research is that: different checkpoint arrangements (within a network of nodes running a given application) exhibit different probabilities (or likelihoods) that the checkpoint data will survive and be useful during execution recovery after a failure arises. This is because each node is typically connected to other system nodes via different wireless links, whose reliability figures vary widely. Sending checkpoint data to a checkpointing provider via an unreliable link is undesirable. We have shown that determining the optimum checkpoint arrangement for a system globally is NP-complete, where the optimum arrangement offers the highest survival probability under the given set of reliability figures for pairs of nodes. As a result, heuristic algorithms are needed to arrive at satisfactory checkpointing arrangements in practice.

Our heuristic starts with partitioning a given system with $N$ nodes into small, non-disjoint clusters, each of which has no more than $k$ ($\ll N$) nodes. To this end, an efficient clustering method has been devised. Various heuristic IID (Independent, Identically Distributed) algorithms are then developed to act upon each cluster individually, with a feasible suboptimal checkpoint arrangement obtained by combining together the results of clusters. We simulate our IID algorithms for comparison with a baseline "quick and dirty" algorithm and with a globally exhaustive search (to get the optimum arrangement), in terms of efficiency (i.e., time taken), traffic overhead, and survival rate (measured by the checkpoint arrangement reliability score for the whole system). The algorithm methodologies and details, their model assumptions, and simulation results are provided.

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