Cloud computing has been prominently existing as an on-demand computing service paradigm and immensely benefiting the small-scale users as well as large-scale commercial and scientific applications.The articles (regarding each fault tolerance method) for inclusion in the paper are selected with the criteria that the reader would be able to know the basic implementations and possible modifications/customization of each fault tolerance method.The fault tolerance methods based on the identified approaches are also explained and hierarchically presented in Section 3.The objective is to provide an evolutionary knowledge base in such a way that the research contribution towards each fault tolerance method could be covered.a quantified view on how much a particular fault tolerance method is utilized in the research.summarises and present a comparative analysis of the existing surveys cited in this paper and the present survey in the context of inclusion (?) and non-inclusion (x) of the attributes: fault taxonomy, fault tolerance approaches, fault tolerance frameworks, comparative analysis, and graphical representation.It is defined as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [1].Anticipating its vast benefits, distinguished IT organizations (such as Amazon, Microsoft, IBM, Google, Yahoo, etc.) are into the foray to deliver cloud services.Therefore, we motivated to write a comprehensive and systematic survey on fault tolerance in cloud by describing its complete structure which includes the description of (a) various fault types, their causes and classification; (b) fault tolerance approaches and techniques; and (c) fault tolerance frameworks.The survey plan is executed through multiple phases described as follows: o Phase-1 (Articles Selection): In the first phase number of research articles (including surveys) related to the field are collected from reputed sources.Section 4 explains various prominent fault tolerance frameworks in the context of basic implementation details, fault applicability, evaluation methodology, and key features.The survey plan broadly includes article selection, fault classification, identification of fault tolerance approaches and methods, description of fault tolerance frameworks, discussion and future directions.On-demand access, resource autonomy, rapid elasticity and always-on availability are the primary characteristics of cloud computing [2].The authors have not included any existing fault tolerance framework in the survey to strengthen the discussion of fault tolerance techniques.Several types of faults and fault tolerance techniques are briefly described in the survey given by Saikia and Devi [20].A comparative analysis of the surveyed frameworks is also given which focuses on the basic approach, methodologies used, fault applicability and key features.Ataallah et al. [19] included a brief description of various fault tolerance parameters in their survey, but failed to include the description of fault types.However, authors have not given any classification of the described faults and fault tolerance techniques in the survey.Further, only a few fault tolerance frameworks are included in the survey without citing any comparative analysis.Amin et al. [18] also enlisted various fault tolerance metrics along with a brief description about fault detection.The collected articles are carefully examined and filtered based on their titles, abstracts, and research contributions.o Phase 4 (Fault Tolerance Frameworks in Cloud): This phase contains the core research contribution of this survey to explain various fault tolerance frameworks proposed in the literature.a comparative analysis of various fault tolerance frameworks described in the survey.Cloud

resources are provisioned using standard protocols (IAM, OAuth, OpenID, etc.Besides this, cloud offers greater business agility at the reduced cost which further attracts a vast user base.A recent survey conducted over 433 enterprise respondents containing 1000+ employees reveals that 95% of the respondents are using cloud [4].Kazarian et al. [5] reported 91% adoption of cloud by the IT professionals in more than 3000 small and midsize businesses.It may be one of the reasons for the reluctance of a big pool of users towards acquiring cloud services and makes fault tolerance as one of the most imperative issues in cloud computing.Fault tolerance is defined as the capability of a system to keep performing its intended task even in the presence of faults [[14], [15]].In the literature, we observe that despite extensive research in the field of fault tolerance in cloud, only a few surveys [[17], [18], [19], [16], [20], [21]] have been published.Necessary efforts are made to assure and maintain the diversity of the articles in order to remove the ambiguity and enhance the knowledge base of the readers.o Phase 3 (Fault Tolerance Approaches in Cloud): In this phase, the collected articles are further analysed to identify various fault tolerance approaches in cloud.Based on the existing challenges observed from the literature, probable future research directions concerning fault tolerance in cloud are given in Section 6.Reliability is a highly significant facet of cloud, as a large number of delay sensitive (real–time) applications are to be executed.Moreover, service reliability is imperative to the wider acceptability of cloud.Therefore, the issue of fault tolerance has got a considerable attention in research and numerous fault tolerance frameworks have been proposed in literature over the period.Although, these surveys have considerable contribution in the field, but in themselves, do not seem to be exhaustive and comprehensive.Cheraghlou et al. [16] gave only a brief description of different fault tolerance techniques without focusing on fault types.[21] focused directly on fault tolerance and classified fault tolerance policies as exclusively handled and collaboratively handled.This survey does not provide view on the conventional classification of the fault tolerance models in cloud.Again, very limited fault tolerance frameworks are explained without any reflection of the methodology of fault tolerance used in the frameworks.It can apparently be concluded that none of the above cited surveys presents the complete structure of fault tolerance in cloud computing.While examining the research contributions, the novelty and quality of the work is critically analysed.o Phase 2 (Fault Classifications in Cloud): In the second phase, the collected articles are intensely scrutinized to identify different fault types in cloud.The identified approaches are enlisted and described in Section 3 of the survey.o Phase 5 (Survey Discussion, Future Directions, and Conclusions): In the last phase, surveyed fault tolerance frameworks are deeply analysed to present the survey results.Section 5 discusses various observations and results drawn from the survey, which includes: ?for authentication; and AMI, OVF, SOAP, REST, etc. for data and workload migration [3]) to create the wider acceptability of cloud services.The cloud computing architecture is dynamic and growing in complexity [[7], [8], [9]].Its deployment uses millions of commodity components rather than conventional ones [10].Fault is an abnormal condition or defect in one or many parts of a system, which may result in the inability of the system to perform its intended functions [11].Error is defined as a deterioration in one or more system components and creates difference between normal and actual state of the system [12].The effects are so adverse at times that they could traumatize the economic state of the service provider.For instance, in 2013, a breakdown of

just about 45 min resulted in an economic loss of $5 million to Amazon cloud [13].Without fault tolerance capability, even a well-designed system with best of the components and services cannot be considered as reliable [16].Through this paper, we endeavour to present a survey of fault tolerance in the cloud computing environment.Agarwal and Sharma [17] gave the taxonomies of fault, error and failure; but missed the theoretical explanation.Very limited frameworks have been explained in this survey which are insufficient to describe the state-of-the-art.In order to understand the complete structure of fault tolerance the readers have to refer different sources.Scope of the present survey is: o Description of various fault types and their causes in cloud computing environment.o Description of different fault tolerance frameworks proposed in literature for cloud computing environment.The identified fault types are thoroughly analysed for their categorization.Though, cloud has gathered much attention over the time, but it is still considered adolescent in terms of fault handling capability [6].Due to this, it is always prone to faults and failures.The errors lead the system to failure, which interrupts the normal delivery of the services and degrades the system performance.Improper handling of system failures may lead the system to an unworkable state [11].Further, the discussion of only a few number of frameworks in the survey limits its scope.o Description of basic fault tolerance approaches used in cloud computing environment.a quantified view on how much a particular fault category is targeted in the research.Fault occurrence creates error in the system.These surveys appear to be limited in respect of one or other account.Section 2 includes the brief description of different fault types, their root causes, and classification in cloud.This phase also includes research directions and survey conclusions.Finally, the paper is concluded in Section 7.Table 1.??