In recent years, online service systems have become increasingly popular. Incidents of these systems could cause significant economic loss and customer dissatisfaction. Incident triage, which is the process of assigning a new incident to the responsible team, is vitally important for quick recovery of the affected service. Our industry experience shows that in practice, incident triage is not conducted only once in the beginning, but is a continuous process, in which engineers from different teams have to discuss intensively among themselves about an incident, and continuously refine the incident-triage result until the correct assignment is reached. In particular, our empirical study on 8 real online service systems shows that the percentage of incidents that were reassigned ranges from 5.43% to 68.26% and the number of discussion items before achieving the correct assignment is up to 11.32 on average. To improve the existing incident triage process, in this paper, we propose DeepCT, a Deep learning based approach to automated Continuous incident Triage. DeepCT incorporates a novel GRUbased (Gated Recurrent Unit) model with an attention-based mask strategy and a revised loss function, which can incrementally learn knowledge from discussions and update incidenttriage results. Using DeepCT, the correct incident assignment can be achieved with fewer discussions. We conducted an extensive evaluation of DeepCT on 14 large-scale online service systems in a multinational technology company M. The results show that DeepCT is able to achieve more accurate and efficient incident triage, e.g., the average accuracy identifying the responsible team precisely is 0.641\_0.729 with the number of discussion items increasing from 1 to 5. Also, DeepCT statistically significantly outperforms the state-of-the-art bug triage approach.