Visual Evaluation of Cloud Infrastructure Performance Predictions

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The workload of an active cloud infrastructure is continuously changing. Administrators need to find the balance between quality of service and cost efficiency. Proactively avoiding performance bottlenecks is a challenging endeavor due to the number and heterogeneity of components in the network, the relationships among them, and the associated attributes. While pattern detection and simulation methods can be used to predict the performance of the network, efficient tools for exploring and evaluating those predictions are missing. In our design study we combine established visualization techniques (CloudGazer [3], ThermalPlot [2], and Linevya [1] for exploring large item collections with custom techniques for investigating predicted time-series data, allowing the administrator to effectively monitor, evaluate, and optimize cloud infrastructure.

ThermalPlot View
The ThermalPlot space maps the criticality of components to the Y-axis and the positive and negative change of the criticality to the Y-axis (see Fig. 2). Consequently, the more critical a component is, the further on the right it will appear in the ThermalPlot space. The position is calculated by the configurable Dof function (see Fig. 1b). Two vertical threshold lines discretize the criticality of components into two states: warning and critical. The administrator can freely configure the thresholds of the states by changing the vertical position of the lines via drag and drop.

Degree-of-Interest (DoI) Function Editor
The Dof function is a weighted sum of multiple performance attributes, such as CPU load, RAM usage, and the number of currently open connections. The exact selection of performance attributes depends on the use case.

Timeline
The timeline shows the selected time range (e.g., 10 hours into the past and 6 hours into the future) for the DoI computation (past to live) and prediction (future). Adjusting the selected time range triggers a re-computation of all DoI values and events.

Predicted Events Ranking
The predicted events are ranked by the predicted performance bottleneck events. Events are the result of a prediction model that uses the historical and live data collection to discover potential bottlenecks. Each event consists of:
- cloud infrastructure component
- specific attribute that is expected to be critical
- estimated timespan until the event occurs (the shorter the closer)
- certainty of prediction (the longer the more likely)
- impact value on the perspective or infrastructure (the longer the bigger)

Recommended Actions
The recommended actions are visualized on the ThermoPlot with the predicted position and a funnel that encloses the certainty (see Fig. 1a). The administrator can therefore easily find which recommendations are most critical.

Figure 1: Design sketch of the proposed visualization concept. (a) The administrator can configure the degree-of-interest (DoI) that determines how critical the status of a component currently is. (b) The ThermalPlot shows the current as well as predicted positions of components in the DoI space. (c) Ranked list of predicted performance bottleneck events. (d) Selected time span with past and future. (e) Ranked list of possible countermeasures for avoiding the future selected bottleneck event. (f) Detail view visualizing the past and predicted item performance using peak bars (collapsed) or as streamgraphs (expanded).

Figure 2: DoI values that change over time result in distinct positions and trajectories of items in the ThermalPlot space.

Figure 3: Detailed view visualizing the past and predicted item performance using peak bars or streamgraphs. Peak bars (collapsed state) visualize DoI values that are above a certain threshold in the corresponding threshold color. The predicted performance changes that are expected for the different recommendations are also visualized using peak bars.

DoI streamgraph (expanded state) visualizes the full time-series data within the selected time span. Available data in the past is visualized as a stacked DoI streamgraph that represents how much each attribute contributes to the aggregated DoI value over time. For predicted future performance values, we show the predicted maximum, expected, and minimum DoI value.