7 APPENDIX

7.1 A Nutshell of Cloud Platform Scoring

7.1.1 Scoring Function

$$\begin{aligned} s_t =& w_1 \cdot m_{ask}(\cdot) + w_2 \cdot m_{dep}(\cdot) \\ &+ w_3 \cdot m_{uti}(\cdot) + w_4 \cdot m_{af}(\cdot) + w_5 \cdot m_{df}(\cdot) \end{aligned} \tag{15}$$

In this function, the user has 3 types of actions: *ask* some quota, *deploy* some quota, and *wait*. Let $\mathcal{H}^t$ be the user's latest action records, which can be treated as a truncated history with a traceback window $|\mathcal{H}^t|$. For each action in $\mathcal{H}^t$, it can be denoted as a tuple (a_i, q_i) where a_i denotes the action type and q_i is the corresponding quota. For example, $a_i = 0$ means this action is "*asking q_i quota*"; $a_i = 1$ means "*deploying q_i quota*", and $a_i = 2$ means "*waiting for nothing*" ($q_i = 0$); $I(\cdot)$ is an indicator; $\lambda > 0$ measures the degree of time decay. A larger λ means the factor focuses more on recent choices. $\gamma > 0$ is a scaled parameter. q_i^{max} is max available quota when action a_i happens in $\mathcal{H}^t$.

To improve the utilization, we wish the user can ask for less quota and deploy the quota as much as possible. Then we can design three factors: ask factor m_{ask}, deploy factor m_{dep}, and utilization factor m_{uti} to encourage users to improve their utilization:

$$\begin{aligned} &m_{ask}\left(t, \{-\gamma_{ask}, \lambda_{ask}\}, \mathcal{H}^t\right) = \\ &\tanh\left(-\gamma_{ask} \cdot \frac{\sum_{i=0}^{|\mathcal{H}^t|} q_i \cdot e^{-\lambda_{ask}\left(|\mathcal{H}^t|-i-1\right)} \cdot I\left(a_i = 0\right)}{\sum_{i=0}^{|\mathcal{H}^t|} I\left(a_i = 0\right)}\right) + 1 \end{aligned} \tag{16}$$

$$\begin{aligned} &m_{dep}\left(t, \{\gamma_{dep}, \lambda_{dep}\}, \mathcal{H}^t\right) = \\ &\tanh\left(\gamma_{dep} \cdot \frac{\sum_{i=0}^{|\mathcal{H}^t|} q_i \cdot e^{-\lambda_{dep}\left(|\mathcal{H}^t|-i-1\right)} \cdot I\left(a_i = 1\right)}{\sum_{i=0}^{|\mathcal{H}^t|} I\left(a_i = 1\right)}\right) \end{aligned} \tag{17}$$

$$\begin{aligned} &m_{uti}\left(t, \{\gamma_{uti}, \lambda_{uti}\}, \mathcal{H}^t\right) = \\ &\tanh\left(\gamma_{uti} \cdot \frac{\sum_{i=0}^{|\mathcal{H}^t|} q_i^{dep}/q_i^{max} \cdot e^{-\lambda_{uti}\left(|\mathcal{H}^t|-i-1\right)}}{\sum_{i=0}^{|\mathcal{H}^t|} e^{-\lambda_{uti}\left(|\mathcal{H}^t|-i-1\right)}}\right) \end{aligned} \tag{18}$$

To improve users' activeness, we wish the user can take effective actions as many as possible. We design two factors to evaluate the user's activity: ask frequency factor m_{af}, and deploy frequency factor s_{df}:

$$\begin{aligned} &m_{af}\left(t, \{\gamma_{af}, \lambda_{af}\}, \mathcal{H}^t\right) = \\ &\tanh\left(-\gamma_{af} \cdot \frac{\sum_{i=0}^{|\mathcal{H}^t|} I\left(a_i = 0\right) \cdot e^{-\lambda_{af}\left(|\mathcal{H}^t|-i-1\right)}}{\sum_{i=0}^{|\mathcal{H}^t|} e^{-\lambda_{af}\left(|\mathcal{H}^t|-i-1\right)}}\right) + 1 \end{aligned} \tag{19}$$

$$\begin{aligned} &m_{df}\left(t, \{\gamma_{df}, \lambda_{df}\}, \mathcal{H}^t\right) = \\ &\tanh\left(\gamma_{df} \cdot \frac{\sum_{i=0}^{|\mathcal{H}^t|} I\left(a_i = 1\right) \cdot e^{-\lambda_{df}\left(|\mathcal{H}^t|-i-1\right)}}{\sum_{i=0}^{|\mathcal{H}^t|} e^{-\lambda_{df}\left(|\mathcal{H}^t|-i-1\right)}}\right) \end{aligned} \tag{20}$$

7.1.2 Reward

The reward of the counter-empirical attacker:

$$r_t = \begin{cases} -0.01 & \text{if } q_t^{dep} > q_{t-1}^{dep}, s_t > s_{t-1} \\ 1.1 * |\Delta s| & \text{if } q_t^{dep} > q_{t-1}^{dep}, s_t \leq s_{t-1} \\ -0.02 & \text{if } q_t^{dep} \leq q_{t-1}^{dep}, s_t < s_{t-1} \\ 1.1 * |\Delta s| & \text{if } q_t^{dep} \leq q_{t-1}^{dep}, s_t \geq s_{t-1} \\ -0.06 & \text{if } q_t^{ask} > 0, s_t < s_{t-1} \\ 1.1 * |\Delta s| & \text{if } q_t^{ask} > 0, s_t \geq s_{t-1} \\ 0 & \text{otherwise} \end{cases} \tag{21}$$

where $\Delta s = s_t - s_{t-1}$. Note that each time only one condition occurs in the above function.

7.2 A Nutshell of Financial Credit Scoring

7.2.1 Scoring Function

$$s^t = w_1 m_{rep}(\cdot) + w_2 m_{con}(\cdot) + w_3 m_{tra}(\cdot) + w_4 m_{wai}(\cdot) \tag{22}$$

Here, users have four action types: *repay* ($a_i = 0$), *consume* ($a_i = 1$), *in-out* ($a_i = 2$), and *inactivity* ($a_i = 3$). Let q^{rep} and q^{con} denote the repaid amount and consumed amount respectively. We consider four factors to encourage good behavior: repay factor m_{rep}, consume factor m_{con}, trade-off factor m_{tra}, wait factor m_{wai}:

$$\begin{aligned} &m_{rep}\left(t, \{\gamma_{rep}, \lambda_{rep}\}, \mathcal{H}^t\right) = \\ &\tanh\left(\gamma_{rep} \sum_{i=0}^{|\mathcal{H}^t|} I(a_i = 0) q_i^{rep} \cdot e^{-\lambda_{rep}\left(|\mathcal{H}^t|-i-1\right)}\right) \end{aligned} \tag{23}$$

$$\begin{aligned} &m_{con}\left(t, \{\gamma_{con}, \lambda_{con}\}, \mathcal{H}^t\right) = \\ &\tanh\left(-\gamma_{con} \sum_{i=0}^{|\mathcal{H}^t|} I(a_i = 1) q_i^{con} \cdot e^{-\lambda_{con}\left(|\mathcal{H}^t|-i-1\right)}\right) + 1 \end{aligned} \tag{24}$$

$$\begin{aligned} &m_{tra}\left(t, \{\gamma_{tra}, \lambda_{tra}\}, \mathcal{H}^t\right) = \\ &\tanh\left(-\gamma_{tra} \sum_{i=0}^{|\mathcal{H}^t|} I(a_i = 2) |\frac{q_i^{con}}{q_i^{rep}} - 1| \cdot e^{-\lambda_{tra}\left(|\mathcal{H}^t|-i-1\right)}\right) + 1 \end{aligned} \tag{25}$$

$$\begin{aligned} &m_{wai}\left(t, \{\gamma_{wai}, \lambda_{wai}\}, \mathcal{H}^t\right) = \\ &\tanh\left(-\gamma_{wai} \sum_{i=0}^{|\mathcal{H}^t|} I(a_i = 3) \cdot e^{-\lambda_{wai}\left(|\mathcal{H}^t|-i-1\right)}\right) + 1 \end{aligned} \tag{26}$$

7.2.2 Reward

$$r_t = \begin{cases} -q^{rep} * |\Delta s| & \text{if } a_t = 0, s_t > s_{t-1} \\ q^{rep} * |\Delta s| & \text{if } a_t = 0, s_t \leq s_{t-1} \\ q^{con} * |\Delta s| & \text{if } a_t = 1, s_t > s_{t-1} \\ -q^{con} * |\Delta s| & \text{if } a_t = 1, s_t \leq s_{t-1} \\ |q^{con}/q^{rep} - 1| * |\Delta s| & \text{if } a_t = 2, s_t > s_{t-1} \\ -|q^{con}/q^{rep} - 1| * |\Delta s| & \text{if } a_t = 2, s_t \leq s_{t-1} \\ 0 & \text{otherwise} \end{cases} \tag{27}$$