From Monetary to Non-Monetary Mechanism Design via Artificial Currencies

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Non-monetary mechanisms for repeated resource allocation are gaining widespread use in many real-world settings. Our aim in this work is to study the allocative efficiency and incentive properties of simple repeated mechanisms based on artificial currencies. Within this framework, we make three main contributions:

- We provide a general black-box technique to convert any static monetary mechanism M to a dynamic mechanism M^* with artificial currency, that simultaneously guarantees *vanishing loss in efficiency*, and *vanishing gains from non-truthful bidding* over time.
- On a computational front, we show how such a mechanism can be implemented using only sample-access to the agents' type distributions, and requires roughly twice the amount of computation as needed to run the monetary mechanism alone.
- For settings with two agents, we show that a particular artificial currency mechanism also results in a *vanishing price of anarchy*. Moreover, we show how to leverage this result to demonstrate the existence of a Bayesian incentive-compatible mechanism with vanishing efficiency loss in this setting.

We informally describe our main result below: Consider a repeated allocation setting with n agents over T periods, where, in each period t, an agent s has a type $\theta_s^t \in \Theta_s$, drawn independently from a distribution F_s. Agents declare their types to a central mechanism, which then chooses an allocation X_t from a set of feasible allocations $\mathcal{X}$. We assume that for a single instance of this allocation problem we are given access to a BIC direct-revelation mechanism M that uses non-negative payments; moreover, we assume that for every agent s there exists a report θ_s that guarantees zero payment.

Given access to T samples $\theta_s^t \in \Theta_s$ for each agent s, we compute c_s^T, the sample average payment of agent s in M under truthful reporting, and allocate each agent s with a budget $B_s = (1+\delta)Tc_s$ of *artificial credits*. We then run M in each period using these credits instead of money. If an agent s runs out of credits, we replace their reports from then on with randomly generated types. Let $u_s(A_s; M)$ be the expected utility of agent s when playing some dynamic strategy A_s under truthful play of other agents. Our main result is as follows:

Theorem. *Let $\lambda > 1$, then for the black-box reduction M^* with $\delta = \Theta(\sqrt{\lambda \log T/T})$, we have*

1. *Truthful reporting* Tr *is an $\alpha = O(\lambda/logT)$-equilibrium under M^*, i.e., for any agent s, assuming all other agents play truthfully, we have: $u_s(\mathrm{Tr}; M^*)/T \geq \sup_{A_s} (u_s(A_s; M^*)/T) - \alpha$.*
2. *M achieves the maximum welfare up to an additive loss $\beta = o(T^{-\lambda})$ per period under truthful reporting, as compared to monetary mechanism M: $W(M^*)/T \geq W(M)/T - \beta$.*

CCS Concepts: •**Theory of computation** → **Algorithmic game theory and mechanism design;** •**Applied computing** → *Electronic commerce; Economics;*

Additional Key Words and Phrases: Mechanisms without money; Artificial currencies; Dynamic mechanisms

A draft of our full paper is available at https://papers.ssrn.com/abstract_id=2964082.

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