Computational Two-Party Correlation

Abstract:

We prove a dichotomy theorem for two-party protocols, and show that for every poly-time two-party protocol with single-bit output, at least one of following holds:

- The protocol can be used to construct a key-agreement protocol.
- For every constant $\frac{1}{\ln} > 0$ the parties' output is $\frac{1}{\ln}$-uncorrelated: let $(X; Y; T)$ denote the parties' outputs and the protocol's transcript respectively. A protocol is $\rho$-uncorrelated if there exists an efficient "decorralizer" algorithm Decor, that when given a random transcript $T$, produces two numbers $P_A; P_B$, such that no efficient algorithm can distinguish $(U_{P_A}; U_{P_B}; T)$ (where $U_p$ denotes a biassed coin with bias $\frac{1}{\ln}$ from $(X; Y; T)$, with distinguishing advantage larger than $\frac{1}{\ln}$.

Namely, if the protocol cannot be used to construct key-agreement, then its output distribution $(X; Y; T)$ is trivial: it can be simulated non-interactively by the parties given public randomness (used to sample $T$). (The precise statement also has qualifiers of the form: "on infinitely many choices of the security parameter").

We use the above characterization to prove that $(\frac{1}{\ln} = 24\mu^2)$-correct differentially private symmetric protocol for computing XOR, implies the existence of key-agreement protocol. The above dependency between $\mu$ and $\epsilon$ is tight since an $\frac{1}{\ln}((\frac{1}{\ln}\mu)^2)$-correct $\epsilon$-differentially private protocol for computing XOR is known to exists unconditionally. It also improves, in the $(\frac{1}{\ln}\mu,\frac{1}{\ln})$dependency aspect, upon Goyal et al. [ICALP '16] who showed that, for some constant $c > 0$, a $c$-correct $\epsilon$-differentially private protocol for computing XOR implies oblivious transfer. Our result extends to a weaker notion of differential privacy in which the privacy only requires to hold against external observer. Interestingly, the reductions used for proving the above results are non black box.

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