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 \( \epsilon > 0 \) the parties' output is \( \epsilon \)-uncorrelated: let \( (X, Y; T) \) denote the parties' outputs and the protocol's transcript respectively. A protocol is \( \epsilon \)-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 \( (U_{\mu}; U_{\nu}; T) \) (where \( U_{\mu} \) denotes a biassed coin with bias \( \mu \) from \( (X, Y; T) \)), with distinguishing advantage larger than \( \epsilon \).

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 \( (1/2 - \epsilon)\)-correct differentially private symmetric protocol for computing XOR, implies the existence of key-agreement protocol. The above dependency between \( \epsilon \) and \( \epsilon \) is tight since an \( 1/2 - \epsilon \)-correct "\( \epsilon \)-differentially private protocol for computing XOR is known to exists unconditionally. It also improves, in the \( (1/2,1/\epsilon)\)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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