About one class polynomial problems with not polynomial certificates

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Abstract. *We build a class of polynomial problems with not polynomial certificates. The parameter concerning which are defined efficiency of corresponding algorithms is the number n of elements of the set has used at construction of combinatory objects (families of subsets) with necessary properties.*

In 1964 Alan Kobham [1] and, independently, in 1965 Jack Edmonds [2] have entered a concept of complexity class P.

Definition 1 [1,2]. A language L belong to P if there is an algorithm A that decide L in polynomial time $(\leq O(n^k))$ for a constant k. Class of problems P is called polynomial.

According to [3] J. Edmonds has entered also the complexity class NP. This is the class of problems (languages) that can be verified by a polynomial-time algorithm.

Definition 2 [3]. A language L belongs to NP if there exists a two-input polynomial-time algorithm A and such polynomial $p(x)$ with whole coefficients that

$L = \{x \in \{0,1\}^n : there\, exists\, a\, certificate\, \mathrm{y}\, with \mid y \mid \leq p(\mid x \mid)\, and\, A(x,y) = 1\}$

In this case we say that the algorithm A verifies language L in polynomial time.

According to definition 2 if $L \in P$ and $\mid y \mid \leq p(\mid x \mid)$ then $L \in NP$. But if $L \in P$ and length of the certificate not polynomial from length x then $L \notin NP$.

J.Edmonds has conjectured also that $P \neq NP$ which so far is not proved.

In 1971 S.A.Cook has put the question: "whether can the verification of correctness of the decision of a problem be more long than the decision itself independently of algorithm of verification?"This problem have a relation to cryptography. In other formulation this problem look so: "whether can be build a cipher such that his decipher algorithmically more complicated than find the cipher?"

The RSA public-key cryptosystem is based on the dramatic difference between the ease of finding large prime numbers and the difficulty of factoring the product of two large prime numbers. In connection with it arise the question in Cook's problem.

In 2008 [4] we have proposed a model of decision Cook's problem: let M and M' are two sets such that M is decidable set in polynomial time, let then there exists the injective map ϕ of M in M' such that for any $m \in M$ $\phi(m)$ find in not polynomial time. In [5,6] we have cited some realizations of this model. Here we cite his yet one realization.

Definition 3 [7]. A family F of subsets of the set S is called Sperner, if no element $A \in F$ is a subset of another element $A' \in F$.

Definition 4 [8-10]. A Sperner family (S.f.) F is called maximal, if for any $A \subset S, A \notin F$, one can find $A' \in F$ such that $A \subset A'$ or $A' \subset A$.

Definition 5 [ibid] We say that a S.f. F has the type $(k, k+1)$, if $\mid A \mid \in \{k, k+1\}$ for any $A \in F$.

Let F be a maximal Sperner family (m.S.f.) of the type $(k, k+1)$, $k \neq 0, n-1$. Thus, we do not consider the m.S.f. $\emptyset$ and S. Let p_i stand for the number of elements $A \in F, \mid A \mid = k$, which do not contain the element $a_i \in S$; let q_i stand for the number of elements $A \in F, \mid A \mid = k+1$ which contain the element a_i. Let $r_i = p_i + q_i, r = max r_i, i = \overline{1,n}$.Evidently, with any $n \geq 3$ the following inequality is true $r_i \leq \binom{n-1}{k}$. It is well-known [8] that studying m.S.f. of the type $(k, k+1)$, it suffices to consider the case $k \leq \lfloor \frac{n}{2} \rfloor$.

If F is a S.f. of the type $(k, k+1)$, then $F^{(k)}, F^{(k+1)}$ stand, correspondingly, for families of subsets $A \in F, \mid A \mid = k, A' \in F, \mid A' \mid = k+1$.

If $F^{(k+1)}$ is family such that for any $A \in F^{(k+1)}$ $a_i \in A$ then we denote by $F^{(k+1)} \backslash \{a_i\}$ the S.f. of the set $S \backslash \{a_i\}$ obtained by expel of each subset $A \in F^{(k+1)}$ of element a_i.

Theorem 1 [9]. If F m.S.f. then $\binom{n-1}{k} \leq \mid F \mid \leq \binom{n}{k+1}$

Definition 6. S.f. $F^{(k+1)}$ is called the admissible fragment of m.S.f. $F' \supset F^{(k+1)}$ if there is $i \in \overline{1, n}$ such that for any $A \in F^{(k+1)}$ $a_i \in A$.

Theorem 2 [6]. There exists the injective map of set admissible fragments $\{F^{(k+1)}\}$ in set of m.S.f. $\{F'\}$ with $r(F') = \binom{n-1}{k}$.

Proof. Let $F^{(k+1)}$ is an admissible fragment such that for any $A \in F^{(k+1)}$ $a_i \in A$. Then we denote by F S.f. $F^{(k+1)} \setminus \{a_i\}$. Let then F_1 is $\{A, \mid A \mid = k, a_i \notin A\} \setminus F$. Evidently family $F' = F^{(k+1)} \bigcup F_1 \bigcup G \bigcup G'$, where G' is family of subsets $A, \mid A \mid = k, a_i \in A$, incomparable by inclusion with elements of $F^{(k+1)}$ and G is family of subset $A', \mid A' \mid = k+1, a_i \notin A'$, incomparable by inclusion with elements of F_1 is the family corresponding the admissible fragment $F^{(k+1)}$. Evidently $r(F') = \binom{n-1}{k}$. The map receiving is injective by construction.

Let n is enough large odd number. We consider S.f. $F^{(\lceil \frac{n}{2} \rceil)}$ of subsets of the set S such that for any $A \in F^{(\lceil \frac{n}{2} \rceil)}$, $a_i \in A$, if $i \in \{1, 2, \ldots, \lceil \frac{n}{2} \rceil - l\}$ where l is a constant. Evidently $\mid F^{(\lceil \frac{n}{2} \rceil)} \mid$ is polynomial of n.

Theorem 3. Family $F^{(\lceil \frac{n}{2} \rceil)}$ is decided in polynomial-time.

Proof. Really since $\mid F^{(\lceil \frac{n}{2} \rceil)} \mid$ is the polynomial from n there exists polynomial algorithm T which in polynomial number of steps definit for any subset $A \subset S$ belongs it $F^{(\lceil \frac{n}{2} \rceil)}$ or no.

We consider two problems: straight (to find $A \in F^{(\lceil \frac{n}{2} \rceil)}$) and reverse (by finding A to build the m.S.f. F' corresponding A). In this connection we suppose $\{A\}$ as the set of ciphers and $\{F'\}$ as the corresponding deciphers. Since $\mid F' \mid > \binom{n-1}{\frac{n-1}{2}}$ is exponent [11] then decipher algorithmically more complex than find the cipher. Thus, at check of correctness of decision the straight problem the length of certificate is not polynomial. From here our straight problem of P does not belong to NP, that is $P \neq NP$.We note at last in addition to [12] once more that the statement $P \subseteq NP$ is error.

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