

ON THE EXISTENCE OF A NEW CLASS OF CONTACT METRIC MANIFOLDS

THEMIS KOUFOGIORGOS and CHARALAMBOS TSICHLIAS

ABSTRACT. A new class of 3-dimensional contact metric manifolds is found.
Moreover it is proved that there are no such manifolds in dimensions greater than 3.

1. Introduction. Let M be a Riemannian manifold. The tangent sphere bundle T_1M admits a contact metric structure (ϕ, ξ, η, g) and so T_1M together with this structure is a contact metric manifold [1]. If M is of constant sectional curvature, then the curvature tensor R of $T_1M(\phi, \xi, \eta, g)$ satisfies the condition

$$(*) \quad R(x, y)\xi = \kappa[\eta(y)x - \eta(x)y] + \mu[\eta(y)hx - \eta(x)hy]$$

for any $x, y \in \mathcal{X}(T_1M)$, where $2h$ is the Lie derivative of ϕ with respect to ξ and κ, μ are constant. Moreover, the converse is also true [3]. This class of contact metric manifolds is especially interesting, because apart from its other characteristics, it contains the well known Sasakian manifolds. In [5],[6],[7] are studied contact metric manifolds satisfying (*) but with κ, μ smooth functions not necessarily constant. In these papers it is proved that, with an extra assumption, the functions κ, μ must be constant. On the other hand, up to now, we didn't know any example of a contact metric manifold satisfying (*) and with κ, μ non constant smooth functions. The following question comes up naturally. Do there exist contact metric manifolds satisfying (*) with κ, μ non-constant smooth functions, independent of the choice of vector fields x, y ? In this paper we give a negative answer to the above question for dimensions > 3 . For dimension 3 we give an affirmative answer, through the construction of examples.

2. Preliminaries. A differentiable $(2m+1)$ -dimensional manifold M^{2m+1} is called a contact manifold if it carries a global differential 1-form η such that $\eta \wedge (d\eta)^m \neq 0$ everywhere on M^{2m+1} . It is known that a contact manifold admits an almost contact metric structure (ϕ, ξ, η, g) , i.e. a global vector field ξ , which will be called the characteristic vector field, a $(1,1)$ tensor field ϕ and a Riemannian metric g such that

$$(2.1) \quad \phi^2 = -Id + \eta \otimes \xi, \quad \eta(\xi) = 1,$$

$$(2.2) \quad g(\phi x, \phi y) = g(x, y) - \eta(x)\eta(y),$$

The authors were supported by G.G.S.R.T (IIENEΔ1995, 388). The second author was also supported by the Institute of State Scholarships of Greece (I.K.Y.)

AMS subject classification: Primary: 53C25 ; secondary : 53C15.

Key words and phrases: Contact metric manifolds, generalized (κ, μ) -contact metric manifolds.

for all vector fields x, y on M^{2m+1} . Moreover, (ϕ, ξ, η, g) can be chosen such that $d\eta(x, y) = g(x, \phi y)$ and thus the structure is called a contact metric structure and the manifold M^{2m+1} a contact metric manifold. Equations (2.1) and (2.2) imply

$$(2.3) \quad \phi\xi = 0, \quad \eta \circ \phi = 0, \quad d\eta(\xi, x) = 0.$$

Denoting by \mathcal{L} and R , Lie differentiation and the curvature tensor respectively, the operators l and h are defined by

$$(2.4) \quad lx = R(x, \xi)\xi, \quad hx = \frac{1}{2}(\mathcal{L}_\xi \phi)x.$$

The (1,1) tensors h and l are self-adjoint and satisfy

$$(2.5) \quad h\xi = 0, \quad l\xi = 0, \quad h\phi + \phi h = 0.$$

If ∇ is the Riemannian connection of g , equations (2.1)-(2.5) imply

$$(2.6) \quad \nabla_x \xi = -\phi x - \phi hx,$$

$$(2.7) \quad \phi l \phi - l = 2(\phi^2 + h^2),$$

$$(2.8) \quad \nabla_\xi \phi = 0,$$

$$(2.9) \quad \nabla_\xi h = \phi - \phi l - \phi h^2.$$

A contact structure on M^{2m+1} gives rise to an almost complex structure on the product $M^{2m+1} \times R$. If this structure is integrable, then the contact metric manifold is said to be Sasakian. Equivalently, a contact metric manifold is Sasakian if and only if

$$(2.10) \quad R(x, y)\xi = \eta(y)x - \eta(x)y.$$

For more details concerning contact manifolds the reader is referred to [1].

3. Main results. Let $M^{2m+1}(\phi, \xi, \eta, g)$ be a contact metric manifold. We suppose that

$$(3.1) \quad R(x, y)\xi = \kappa[\eta(y)x - \eta(x)y] + \mu[\eta(y)hx - \eta(x)hy],$$

for some smooth functions κ and μ on M independent of the choice of vector fields x and y . We call such a manifold M , a *generalized (κ, μ) -contact metric manifold*. In the special case $\kappa, \mu = \text{constant}$, the manifold will be called simply a (κ, μ) -contact metric manifold.

The 3-dimensional case, ($m=1$). Now, we are going to construct examples of 3-dimensional generalized (κ, μ) -contact metric manifolds, which are not (κ, μ) -contact metric manifolds.

Example 1. We consider the 3-dimensional manifold $M = \{(x_1, x_2, x_3) \in R^3 | x_3 \neq 0\}$, where (x_1, x_2, x_3) are the standard coordinates in R^3 . The vector fields

$$e_1 = \frac{\partial}{\partial x_1}, \quad e_2 = -2x_2x_3 \frac{\partial}{\partial x_1} + \frac{2x_1}{x_3^3} \frac{\partial}{\partial x_2} - \frac{1}{x_3^2} \frac{\partial}{\partial x_3}, \quad e_3 = \frac{1}{x_3} \frac{\partial}{\partial x_2}$$

are linearly independent at each point of M . Let g be the Riemannian metric defined by $g(e_i, e_j) = \delta_{ij}$, $i, j = 1, 2, 3$. Let ∇ be the Riemannian connection and R the curvature tensor of g . We easily get

$$[e_1, e_2] = \frac{2}{x_3^2} e_3, \quad [e_2, e_3] = 2e_1 + \frac{1}{x_3^3} e_3, \quad [e_3, e_1] = 0.$$

Let η be the 1-form defined by $\eta(z) = g(z, e_1)$ for any $z \in \mathcal{X}(\mathcal{M})$. Because $\eta \wedge d\eta \neq 0$ everywhere on M , η is a contact form. Let ϕ be the (1,1)-tensor field, defined by $\phi e_1 = 0$, $\phi e_2 = e_3$, $\phi e_3 = -e_2$. Using the linearity of ϕ , $d\eta$ and g we find $\eta(e_1) = 1$, $\phi^2 z = -z + \eta(z)e_1$, $d\eta(z, w) = g(z, \phi w)$ and $g(\phi z, \phi w) = g(z, w) - \eta(z)\eta(w)$ for any $z, w \in \mathcal{X}(\mathcal{M})$. Hence (ϕ, e_1, η, g) defines a contact metric structure on M and so M together with this structure is a contact metric manifold.

Putting $\xi = e_1$, $x = e_2$, $\phi x = e_3$ and using the well known formula

$$2g(\nabla_y z, w) = yg(z, w) + zg(w, y) - wg(y, z) - g(y, [z, w]) - g(z, [y, w]) + g(w, [y, z])$$

we calculate

$$\begin{aligned} \nabla_x \xi &= -(1 + \frac{1}{x_3^2})\phi x, \quad \nabla_{\phi x} \xi = (1 - \frac{1}{x_3^2})x, \quad \nabla_\xi x = (-1 + \frac{1}{x_3^2})\phi x, \quad \nabla_\xi \phi x = (1 - \frac{1}{x_3^2})x \\ \nabla_x x &= 0, \quad \nabla_x \phi x = (1 + \frac{1}{x_3^2})\xi, \quad \nabla_{\phi x} x = (-1 + \frac{1}{x_3^2})\xi - \frac{1}{x_3^3}\phi x, \quad \nabla_{\phi x} \phi x = \frac{1}{x_3^3}x. \end{aligned}$$

Therefore for the tensor field h we get $h\xi = 0$, $hx = \lambda x$, $h\phi x = -\lambda\phi x$, where $\lambda = \frac{1}{x_3^2}$.

Now, putting $\mu = 2(1 - \frac{1}{x_3^2})$ and $\kappa = \frac{x_3^4 - 1}{x_3^4}$ we finally get

$$\begin{aligned} R(x, \xi)\xi &= \kappa(\eta(\xi)x - \eta(x)\xi) + \mu(\eta(\xi)hx - \eta(x)h\xi) \\ R(\phi x, \xi)\xi &= \kappa(\eta(\xi)\phi x - \eta(\phi x)\xi) + \mu(\eta(\xi)h\phi x - \eta(\phi x)h\xi) \\ R(x, \phi x)\xi &= \kappa(\eta(\phi x)x - \eta(x)\phi x) + \mu(\eta(\phi x)hx - \eta(x)h\phi x). \end{aligned}$$

These relations yield the following, by a straightforward calculation,

$$R(z, w)\xi = \kappa(\eta(w)z - \eta(z)w) + \mu(\eta(w)hz - \eta(z)hw),$$

where κ and μ are non-constant smooth functions. Hence M is a generalized (κ, μ) -contact metric manifold.

Example 2. We consider the 3-dimensional manifold $M = \{(x_1, x_2, x_3) \in \mathbb{R}^3 | x_3 \neq 0\}$ and the vector fields

$$e_1 = \frac{\partial}{\partial x_1}, \quad e_2 = \frac{1}{x_3^2} \frac{\partial}{\partial x_2}, \quad e_3 = 2x_2x_3^2 \frac{\partial}{\partial x_1} + \frac{2x_1}{x_3^6} \frac{\partial}{\partial x_2} + \frac{1}{x_3^6} \frac{\partial}{\partial x_3}.$$

We define ξ, g, η, ϕ by $\xi = e_1$, $g(e_i, e_j) = \delta_{ij}$, $(i, j = 1, 2, 3)$ and $\phi e_1 = 0$, $\phi e_2 = e_3$, $\phi e_3 = -e_2$. Working as in the previous example we finally get that $M(\phi, \xi, \eta, g)$ is a generalized (κ, μ) -contact metric manifold with $\kappa = 1 - \frac{1}{x_3^8}$, $\mu = 2(1 + \frac{1}{x_3^4})$.

Let us give some more examples. Starting with the examples given previously we will now construct new 3-dimensional generalized (κ, μ) -contact metric manifolds for any positive real number.

Let $M(\phi, \xi, \eta, g)$ be a 3-dimensional generalized (κ, μ) -contact metric manifold. By a D_a -homothetic deformation [8] we mean a change of structure tensors of the form $\bar{\eta} = a\eta$, $\bar{\xi} = \frac{1}{a}\xi$, $\bar{\phi} = \phi$, $\bar{g} = ag + a(a-1)\eta \otimes \eta$, where a is a positive constant. It is well known that $M(\bar{\phi}, \bar{\xi}, \bar{\eta}, \bar{g})$ is also a contact metric manifold. Moreover the curvature tensor R and the tensor h transform in the following manner [3], $\bar{h} = \frac{1}{a}h$ and

$$a\bar{R}(x, y)\bar{\xi} = R(x, y)\xi + (a-1)^2(\eta(y)x - \eta(x)y) - (a-1)\{(\nabla_x \phi)y - (\nabla_y \phi)x + \eta(x)(y + hy) - \eta(y)(x + hx)\},$$

for any $x, y \in \mathcal{X}(\mathcal{M})$.

Additionally it is well known [9, pp. 446-447], that any 3-dimensional contact metric manifold satisfies $(\nabla_x \phi)y = g(x + hx, y)\xi - \eta(y)(x + hx)$. Using the above relations we finally obtain

$$\bar{R}(x, y)\bar{\xi} = \frac{\kappa + a^2 - 1}{a^2}(\bar{\eta}(y)x - \bar{\eta}(x)y) + \frac{\mu + 2(a-1)}{a}(\bar{\eta}(y)\bar{h}x - \bar{\eta}(x)\bar{h}y)$$

for any $x, y \in \mathcal{X}(\mathcal{M})$. So we have proved the following Theorem.

THEOREM 3.1. *For any positive number, there exists a 3-dimensional generalized (κ, μ) -contact metric manifold.*

The case $m > 1$. Let $M^{2m+1}(\phi, \xi, \eta, g)$ be a generalized (κ, μ) -contact metric manifold and $B = \{p \in M / \kappa(p) = 1\}$. The set $N = M - B$ is an open subset of M and thus $N^{2m+1}(\phi, \xi, \eta, g)$ is a contact metric manifold, which satisfies the equation (3.1) with $\kappa \neq 1$ everywhere.

LEMMA 3.2. *The following relations are valid on $N^{2m+1}(\phi, \xi, \eta, g)$*

$$(3.2) \quad l\phi - \phi l = 2\mu h\phi,$$

$$(3.3) \quad h^2 = (\kappa - 1)\phi^2, \quad \kappa < 1$$

$$(3.4) \quad R(\xi, x)y = \kappa[g(x, y)\xi - \eta(y)x] + \mu[g(hx, y)\xi - \eta(y)hx],$$

$$(3.5) \quad (\nabla_x h)y - (\nabla_y h)x = (1 - \kappa)[2g(x, \phi y)\xi + \eta(x)\phi y - \eta(y)\phi x] + (1 - \mu)[\eta(x)\phi hy - \eta(y)\phi hx],$$

$$(3.6) \quad \xi\kappa = 0.$$

for any $x, y \in \mathcal{X}(N)$.

PROOF. The proof of (3.2)-(3.5) is similar to that of Lemma 3.1 of [3] and hence we omit it. To prove (3.6), we operate (3.2) by ϕ and use (2.7) and (3.3) we get $l = -\kappa\phi^2 + \mu h$ and so through (2.8) we find

$$(3.7) \quad \nabla_\xi l = -(\xi\kappa)\phi^2 + (\xi\mu)h + \mu(\nabla_\xi h).$$

Moreover from (2.9), (3.3) and $l = -\kappa\phi^2 + \mu h$ we obtain

$$(3.8) \quad \nabla_\xi h = \mu h \phi.$$

The use of (3.8) in (3.7) shows

$$(3.9) \quad \nabla_\xi l = -(\xi\kappa)\phi^2 + (\xi\mu)h + \mu^2 h \phi.$$

Differentiating (2.7) along ξ and using (3.8) we get $\phi(\nabla_\xi l)\phi - \nabla_\xi l = 0$. This together with (3.9) complete the proof of the Lemma.

LEMMA 3.3 *For any vector fields x, y on a $(2m + 1)$ -dimensional generalized (κ, μ) -contact metric manifold the following differential equation is valid*

$$(3.10) \quad (y\kappa)\phi^2 x - (x\kappa)\phi^2 y + (x\mu)hy - (y\mu)hx + (\xi\mu)[\eta(y)hx - \eta(x)hy] = 0.$$

PROOF. Differentiating (3.1) along an arbitrary vector field z and using (2.6) we find

$$\begin{aligned} \nabla_z R(x, y)\xi &= (z\kappa)[\eta(y)x - \eta(x)y] + (z\mu)[\eta(y)hx + \eta(x)hy] \\ &+ \kappa[(\eta(\nabla_z y) - g(y, \phi z) - g(y, \phi hz))x + \eta(y)\nabla_z x \\ &- (\eta(\nabla_z x) - g(x, \phi z) - g(x, \phi hz))y + \eta(x)\nabla_z y] \\ &+ \mu[(\eta(\nabla_z y) - g(y, \phi z) - g(y, \phi hz))hx + \eta(y)\nabla_z hx \\ &- (\eta(\nabla_z x) - g(x, \phi z) - g(x, \phi hz))hy + \eta(x)\nabla_z hy]. \end{aligned}$$

The use of the last relation, (3.1) and (2.6) in Bianchi second identity yield to the following relation, by a direct calculation,

$$\begin{aligned} &\oplus_{\{x, y, z\}} \{ (z\kappa)[\eta(y)x - \eta(x)y] + (z\mu)[\eta(y)hx + \eta(x)hy] \\ &+ \kappa[(\eta(\nabla_z y) - g(y, \phi z) - g(y, \phi hz))x + \eta(y)\nabla_z x \\ &- (\eta(\nabla_z x) - g(x, \phi z) - g(x, \phi hz))y + \eta(x)\nabla_z y] \\ &+ \mu[(\eta(\nabla_z y) - g(y, \phi z) - g(y, \phi hz))hx + \eta(y)\nabla_z hx \\ &- (\eta(\nabla_z x) - g(x, \phi z) - g(x, \phi hz))hy + \eta(x)\nabla_z hy] \\ &- \kappa[\eta(y)\nabla_z x - \eta(\nabla_z x)y] - \mu[\eta(y)h\nabla_z x - \eta(\nabla_z x)hy] \\ &- \kappa[\eta(\nabla_x z)y - \eta(y)\nabla_x z] - \mu[\eta(\nabla_x z)hy - \eta(y)h\nabla_x z] \\ &+ R(x, y)\phi z + R(x, y)\phi hz \} = 0, \end{aligned}$$

where $\oplus_{\{x, y, z\}}$ denotes the cyclic sum of x, y, z . Putting ξ instead of z in the last relation and using (3.4) and (3.6) we obtain

$$\begin{aligned} &-(y\kappa)x + (x\kappa)y + [(\xi\mu)\eta(y) - (y\mu)]hx + [-(\xi\mu)\eta(x) + (x\mu)]hy \\ &+ \eta(y)(\nabla_\xi h)x - \mu\eta(x)(\nabla_\xi h)y + \mu(\nabla_x h)y - \mu(\nabla_y h)x \\ &+ [-(x\kappa)\eta(y) + (y\kappa)\eta(x) + \kappa(g(y, \phi hx) - g(x, \phi hy)) \\ &+ \mu(g(hx, \phi hy) - g(hy, \phi hx) - g(hy, \phi x) + g(hx, \phi y))]\xi \\ &- \mu\eta(x)h\nabla_y \xi - \mu\eta(y)h\nabla_x \xi = 0. \end{aligned}$$

Substituting (2.1), (2.5) and (3.5) in the last relation we finally get (3.10) and it completes the proof of the Lemma.

LEMMA 3.4. *For any $P \in N$ there exist an open neighbourhood U of P and orthonormal local vector fields $x_i, \phi x_i, \xi, i = 1, \dots, m$, defined on U , such as*

$$(3.11) \quad hx_i = \lambda x_i, \quad h\phi x_i = -\lambda \phi x_i, \quad h\xi = 0, \quad i = 1, \dots, m,$$

where $\lambda = \sqrt{1 - \kappa}$.

PROOF. Using (3.3), we see that, at any point of N the tensor h has three eigenvalues; 0 with multiplicity 1, $\sqrt{1 - \kappa}$ with multiplicity m and $-\sqrt{1 - \kappa}$ with multiplicity m . The function $\lambda = \sqrt{1 - \kappa}$ is smooth on N . Let $y_1, \dots, y_m, y_{m+1}, \dots, y_{2m}, y_{2m+1}$, be a basis of $T_P N$, such that, $hy_i = \lambda y_i, i = 1, \dots, m$, $hy_j = -\lambda y_j, j = m+1, \dots, 2m$, $y_{2m+1} = \xi$. We extend y_i 's to vector fields on N and define the vector fields $w_i = (h + \lambda I)y_i - \lambda \eta(y_i)\xi, i = 1, \dots, m$, $w_j = (h - \lambda I)y_j + \lambda \eta(y_j)\xi, j = m+1, \dots, 2m$ and ξ . At P we have $w_i = 2\lambda y_i, i = 1, \dots, m$, and $w_j = -2\lambda y_j, j = m+1, \dots, 2m$. Thus $w_1, \dots, w_m, w_{m+1}, \dots, w_{2m}, \xi$ are linearly independent at P and hence in a neighbourhood U of P . At each point of U we have

$$\begin{aligned} hw_i &= h((h + \lambda I)y_i - \lambda \eta(y_i)\xi) = \lambda w_i, \quad i = 1, \dots, m, \\ hw_j &= h((h - \lambda I)y_j + \lambda \eta(y_j)\xi) = -\lambda w_j, \quad j = m+1, \dots, 2m, \\ h\xi &= 0. \end{aligned}$$

The vector fields $\xi, x_i = \frac{w_i}{|w_i|}$ and $\phi x_i, i = 1, \dots, m$, satisfy (3.11) and so the proof is completed.

From now on, we will call the vector fields of Lemma 3.4 a local h -basis. We suppose that $\{x_i, \phi x_i, \xi\}, i = 1, \dots, m$, is a local h -basis on N . Substituting $x = x_i, y = \phi x_i$ in (3.10) we get

$$(3.12) \quad \lambda x_i \mu = x_i \kappa, \quad -\lambda \phi x_i \mu = \phi x_i \kappa, \quad i = 1, \dots, m.$$

Since $m > 1$, replacing x, y by $x_i, x_j (i \neq j)$ respectively, equation (3.10) gives

$$(3.13) \quad -\lambda x_i \mu = x_i \kappa, \quad i = 1, \dots, m.$$

Finally, substituting $x = \phi x_i, y = \phi x_j, (i \neq j)$, in (3.10) we have

$$(3.14) \quad \lambda \phi x_i \mu = \phi x_i \kappa, \quad i = 1, \dots, m.$$

By virtue of (3.6), (3.12), (3.13) and (3.14) we obtain

$$(3.15) \quad x_i \kappa = \phi x_i \kappa = \xi \kappa = x_i \mu = \phi x_i \mu = 0, \quad i = 1, \dots, m.$$

Considering the 1-form $d\mu$ and using (3.15) we have $d\mu = (\xi \mu)\eta$, and so

$$(3.16) \quad 0 = d^2 \mu = d(\xi \mu) \wedge \eta + (\xi \mu) d\eta.$$

Using (3.15) and (3.16) we obtain $d(\xi\mu) = \xi(\xi\mu)\eta$ and so $\xi\mu = 0$. This together with (3.15) show that the functions κ and μ are constant on N . Therefore by the continuity of κ, μ we conclude that the functions κ, μ are constant on M . If $\kappa \equiv 1$, then using $h^2 = (\kappa - 1)\phi^2$, which is valid on any (κ, μ) -contact metric manifold, we get $h = 0$ and so by (3.1) and (2.10) M is Sasakian manifold.

So we have proved the following Theorem.

THEOREM 3.5. *On a non Sasakian, generalized (κ, μ) -contact metric manifold M^{2m+1} with $m > 1$, the functions κ, μ are constant, i.e. M^{2m+1} is a (κ, μ) -contact metric manifold.*

Using Lemma 3.3, for the 3-dimensional case, and working as in the case $m > 1$, we easily prove the following Theorem.

THEOREM 3.6. *Let M be a non Sasakian, generalized (κ, μ) -contact metric manifold. If κ, μ satisfy the condition $a\kappa + b\mu = c$ (a, b, c , constant), then κ, μ are constant.*

REMARKS. 1. If $\kappa = \mu = 0$, then $R(x, y)\xi = 0$ and such a contact metric manifold M^{2m+1} is locally the product of a flat $(m + 1)$ -dimensional manifold and an m -dimensional manifold of constant curvature 4, [2].

2. Recently, we have been informed by D.E. Blair, that (κ, μ) -contact metric manifolds have been classified, [4]. For the 3-dimensional case see also [3].

ACKNOWLEDGMENT. The authors thank the referee for his suggestions.

REFERENCES

1. D.E. Blair, *Contact manifolds in Riemannian geometry*. Lecture Notes in Mathematics 509, Springer-Verlag, Berlin, 1976.
2. D.E. Blair, *Two remarks on contact metric structures*. Tohoku Mathematical Journal 29(1977), 319-324.
3. D.E. Blair, T. Koufogiorgos and B. Papantoniou, *Contact metric manifolds satisfying a nullity condition*. Israel Journal of Mathematics 91 (1995), 189-214.
4. E. Boeckx, *A full classification of contact metric (κ, μ) -spaces*, preprint.
5. F. Gouli-Andreou and P.J. Xenos, *A class of contact metric 3-manifolds with $\xi \in N(\kappa, \mu)$ and κ, μ functions*. To appear in Algebras Groups and Geometries.
6. F. Gouli-Andreou and P.J. Xenos, *Two classes of conformally flat contact metric 3-manifolds*. To appear in Journal of Geometry.
7. R. Sharma, *On the curvature of contact metric manifolds*. Journal of Geometry, 53(1995), 179-190.
8. S. Tanno, *The topology of contact Riemannian manifolds*. Illinois Journal of Mathematics 12(1968), 700-717.
9. S. Tanno, *Variational problems on contact Riemannian manifolds*. Trans. A.M.S. 314(1989), 349-379.

Department of Mathematics
University of Ioannina
Ioannina 45110, Greece
email addresses: tkoufogl@cc.uoi.gr
ctsichli@cc.uoi.gr