One parameter 3-equipped posets

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Alexander G. Zavadskij introduced partially ordered sets with an order relation of two kinds and called them equipped posets (actually we call them 2-equipped, in the sense of generalized equipped posets).

A.V. Zabarilo and A.G. Zavadskij, *One-parameter equipped posets and their representations*. Functional. Anal.i Prilozhen., **34** (2000), no. 2, 72-75 (Russian), English transl. in Functional Anal. Appl., **34** (2000), no.2, 138-140.

Their representations are modules over certain artinian shurian algebras over a non-algebraically closed field. They determine some matrix problems of mixed type over a quadratic field extension.

A.G. Zavadskij, *Tame equipped posets*. Linear Algebra and its Appl., Vol. **365** (2003), 389-465.

A.G. Zavadskij, *Equipped posets of finite growth*. Representations of Algebras and Related Topics, AMS, Fields Inst. Comm. Ser., Vol. **45**(2005), 363-396.

C. Rodriguez and A.G. Zavadskij, *On corepresentations of equipped posets and their differentiation*. Revista Colombiana de Matematicás, **41** (2007), 117-142.

3-equipped posets

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- Classification of indecomposable representations and corepresentations of the sincere one parameter 3-equipped posets, in evident matrix.
- Properties of dimension vectors of indecomposable representations and corepresentations of three-equipped posets, in terms of the Tits quadratic form.

3-equipped poset

Definition

A finite poset $(\mathcal{P}, \leq)$ is called 3-equipped if to every comparable pair of its points $x \leq y$, we assign one and only one value

$$x \leq^{1} y \quad \text{or} \quad x \leq^{2} y \quad \text{or} \quad x \leq^{3} y$$

and the following condition holds:

$$\text{If } x \leq^{l} y \leq^{m} z \text{ and } x \leq^{n} z, \text{ then } n \geq \text{mín}\{lm, 3\}.$$

3-equipped poset

We use the terminology:

if $x \leq^1 y$ we say that x and y are in weak relation,
if $x \leq^2 y$ we say that x and y are in semistrong relation,
if $x \leq^3 y$ we say that x and y are in strong relation.

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For every point $x \in \mathcal{P}$ we have $x \leq^1 x$, or $x \leq^3 x$.

Points

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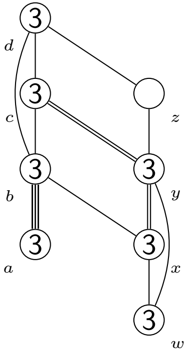
Any relation between a strong point and an arbitrary point is always strong.

Ordinary posets as 3-equipped posets

A 3-equipped poset $(\mathcal{P}, \leq)$ is called trivially equipped if it contains only strong points; in this case $(\mathcal{P}, \leq)$ is an ordinary poset.

Example of a 3-equipped poset



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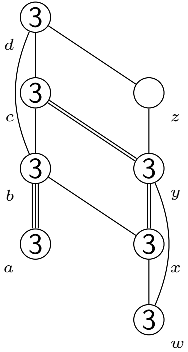

$$\{w, x, y\} <^3 z <^3 d$$

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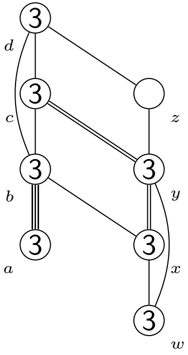

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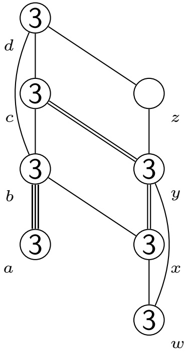

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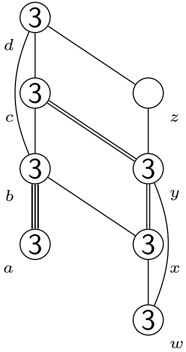

$\{w, x, y\} <^3 z <^3 d$

$x <^2 y <^2 c \Rightarrow x <^3 c$

$w <^3 y$ though $w <^1 x <^2 y$

Representations and corepresentations

Cubic field extension

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$G = F(\xi)$.

A natural derivation over the field G

The derivation δ over the field G, is the application $\delta : \mathsf{G} \to \mathsf{G}$ such that

$$\delta(a) = 0, \text{ for every } a \in \mathsf{F}, \quad \delta(\xi) = 1, \quad \delta(\xi^2) = -\xi.$$

For each $g \in \mathsf{G}$, we denote $g^\delta = \delta(g)$.

As $g \in \mathsf{G}$ can be written $g = a + b\xi + c\xi^2$ for some $a, b, c \in \mathsf{F}$, notice that $g^\delta = b - c\xi$.

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δ appears in a natural way when we are solving the matrix problem corresponding to some critical 3-equipped poset.

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Representations of 3-equipped posets

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Two representations U and V are isomorphic $(U \simeq V)$ if and only if there exists a F-vector space isomorphism $\varphi : U_0 \to V_0$ such that $(\varphi \otimes 1)(U_x) = V_x$ for all $x \in \mathcal{P}$.

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We apply the following admissible transformations to M.

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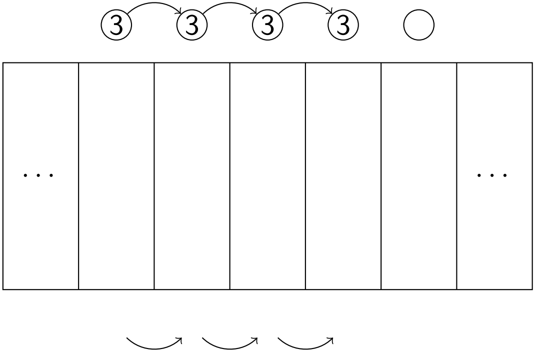

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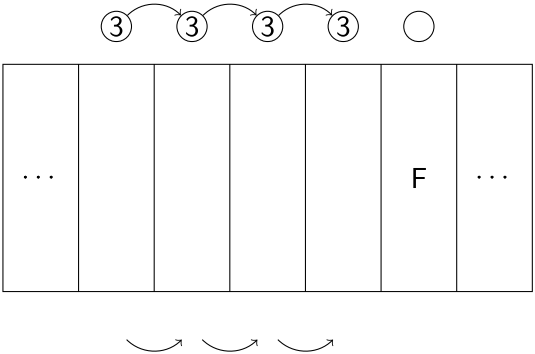

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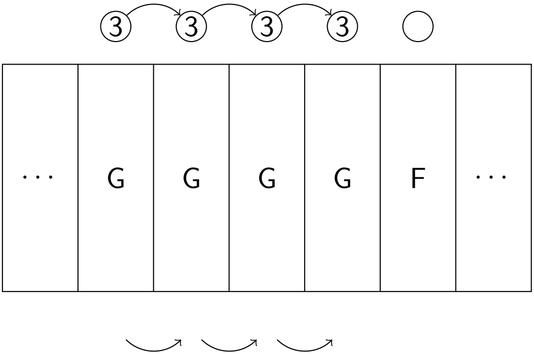

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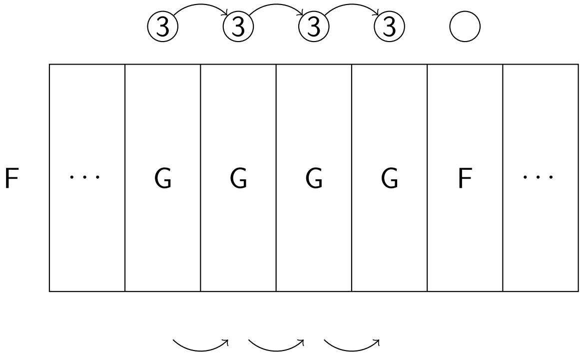

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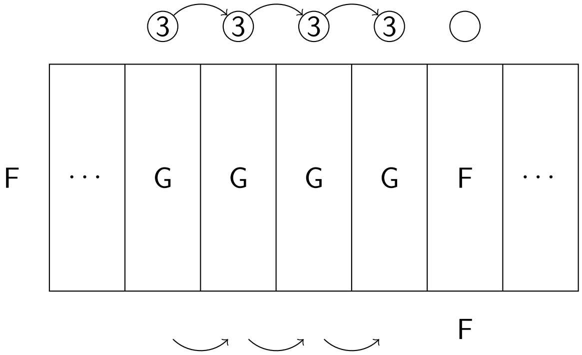

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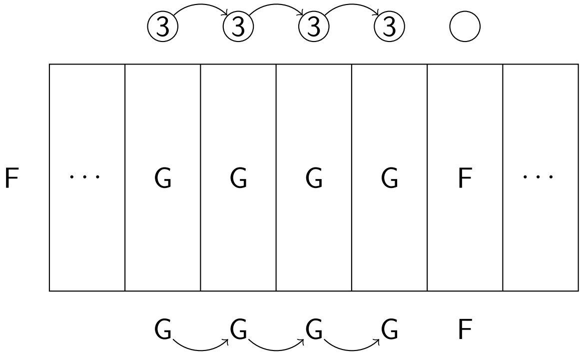

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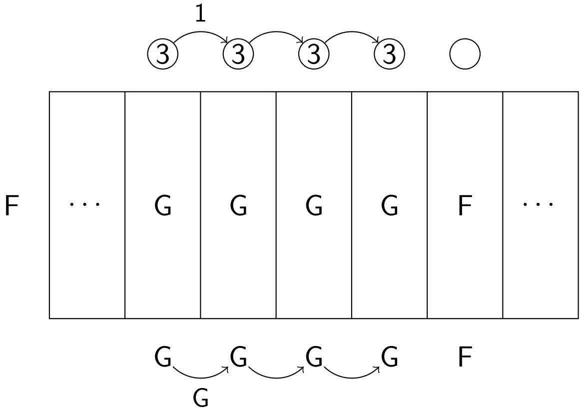

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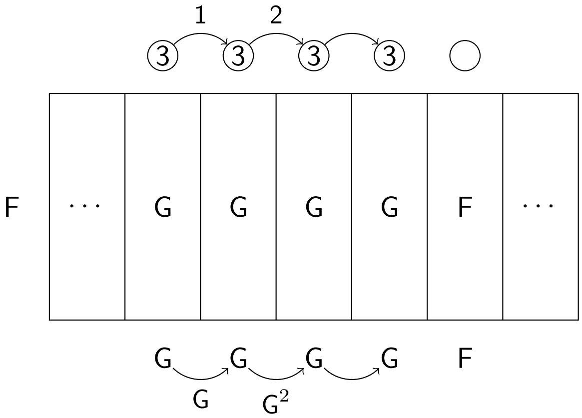

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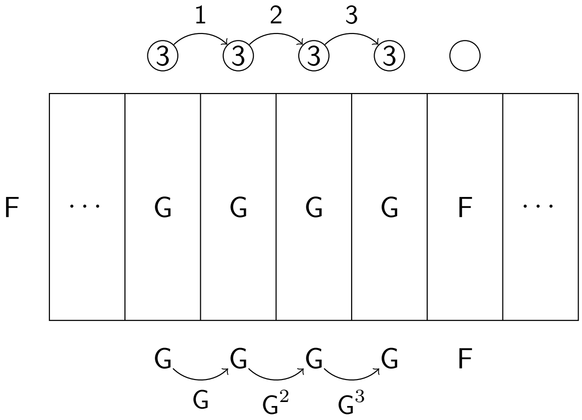

Corepresentations of 3-equipped posets

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Its admissible transformations are the following

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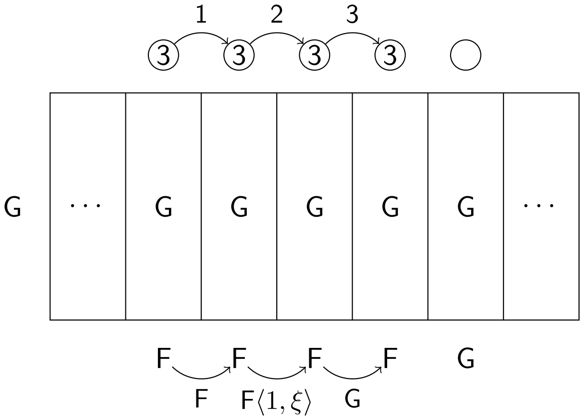

One parameter 3-equipped posets

Series

We define matrix representations and corepresentations over the pair of polynomial rings $(\mathsf{F}[t], \mathsf{G}[t])$, as we did over the pair (F,G).

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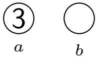
Each representation over $(\mathsf{F}[t], \mathsf{G}[t])$ generates an F-series of representations over (F,G) by substituting a square matrix A (in a standard canonical form) with values in F for the variable t, and scalar matrices gI of the same size, for each scalar element $g \in \mathsf{G}$.

Example of an F-series

For the poset K_{10}



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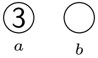

the representation

a	b
1	1
ξ	t

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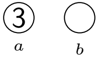

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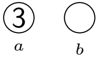

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where A is a matrix over F, of order n in a standard canonical form with respect to ordinary similarity transformations $(X^{-1}AX)$ over F.

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If M is a $(\mathsf{F}[t], \mathsf{G}[t])$-representation such that the variable t does not appear in the stripes corresponding to the strong points, then M generates a G-series of representations over (F,G) by substituting a square matrix A (in a standard canonical form) with values in G for the variable t, and scalar matrices gI of the same size, for each scalar element $g \in$ G.

Example of a G-series

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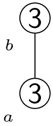

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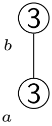
For the poset K_{11} 

the representation

a	b
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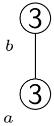

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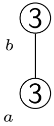
Example of a G-series

For the poset K_{11}



the representation

a	b
1	0
ξ	1
ξ^2	t

generates the G-series

a	b
I	0
ξI	I
$\xi^2 I$	A

where A is a matrix over G,

of order n in a standard canonical form with respect to the following pseudolinear similarity transformations over G,

$$X^{-1}AX + X^{-1}X^{\delta}$$

Corepresentation series

Every matrix corepresentation over the pair of polynomial rings $(\mathsf{F}[t], \mathsf{G}[t])$ generates an F(G)-series of corepresentations over (F,G) by substituting a square matrix A (in a standard canonical form) with values in F (G) for the variable t, and scalar matrices gI of the same size, for each scalar element $g \in \mathsf{G}$.

One parameter 3-equipped posets

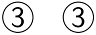
A 3-equipped poset $(\mathcal{P}, \leq)$ is one parameter, if it is of infinite type and there exists one series, in each dimension, containing almost all its indecomposable representations or corepresentations (up to isomorphism).

One parameter criterion for 3-equipped posets

THEOREM 1

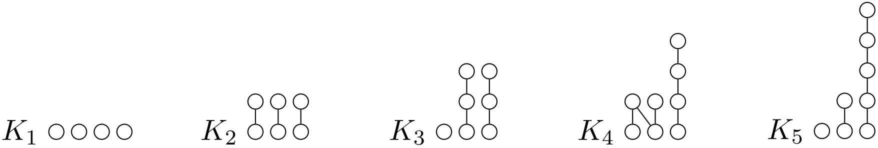
Let F be a field of characteristic 3, G be an inseparable cubic extension over F, and $(\mathcal{P}, \leq)$ be a 3-equipped poset. Then the following statements are equivalent:

1. $\mathcal{P}$ is one parameter with respect to representations and corepresentations.
2. $\mathcal{P}$ contains exactly one of the critical 3-equipped posets $K_1, \ldots, K_5$, K_{10}, K_{11} as a subposet, and does not contain the poset W_{10} of the form



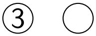
Critical 3-equipped posets

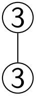
The first five posets in the list are the Kleiner's critical posets.



Critical 3-equipped posets

The last two are the (non-trivially equipped) critical 3-equipped posets.

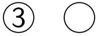
K_{10}


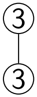
K_{11}


Sincere one parameter 3-equipped posets

THEOREM 2

The only sincere one parameter 3-equipped posets, which are not ordinary, are the critical K_{10} and K_{11}.

K_{10} 

K_{11} 

Indecomposables of one parameter 3-equipped posets

THEOREM 3

The sincere indecomposables of the critical 3-equipped poset K_{10} are exhausted, up to isomorphism, by:

(I) 33 kinds of pairwise non-isomorphic sincere indecomposable matrix representations.

(II) 33 kinds of pairwise non-isomorphic sincere indecomposable matrix corepresentations.

Indecomposables of one parameter 3-equipped posets

THEOREM 4

The sincere indecomposables of the critical 3-equipped poset K_{11} are exhausted, up to isomorphism, by:

(I) 29 kinds of pairwise non-isomorphic sincere indecomposable matrix representations.

(II) 29 kinds of pairwise non-isomorphic sincere indecomposable matrix corepresentations.

Representations of K_{10}

One series

$$f = 0$$

I	I
ξI	A

where A is a matrix of order n in a standard canonical form with respect to similarity $(X^{-1}AX)$ over F.

Representations of K_{10}

$$f = 0$$

1	0	0	1	0	0
ξ	1	0	0	0	0
ξ^2	$-\xi$	0	0	0	0
0	0	1	1	0	0
0	0	ξ	0	1	0
0	0	ξ^2	0	0	1

Representations of K_{10}

$f = 3$

1	0	1	0	0
ξ	1	0	1	0
ξ^2	$-\xi$	0	0	1

$f = 3$

1	0	0	0	1	0	0
0	1	0	0	0	1	0
ξ	0	1	0	0	0	1
0	ξ	0	1	0	0	0
ξ^2	0	$-\xi$	0	0	0	0
0	ξ^2	0	$-\xi$	0	0	1

Representations of K_{10}

$f = 3$

1	0	1	0	0
0	1	0	1	0
ξ	0	0	0	1
0	ξ	0	0	0
ξ^2	0	0	0	0
0	ξ^2	0	0	1

$f = 3$

1	0	0	0	0	0	0
0	1	0	0	0	0	0
0	0	1	0	0	0	0
ξ	0	0	0	0	0	1
0	ξ	0	0	0	1	0
0	0	ξ	0	1	0	0
0	0	0	1	1	0	0
0	0	0	ξ	0	1	0
0	0	0	ξ^2	0	0	1

Corepresentations of K_{10}

One series

$$\widehat{f} = 0$$

I	ξI	$\xi^2 I$	I
0	I	$-\xi I$	A

where A is a matrix of order n in a stander canonical form with respect to pseudolinear $(I + X^{-1}AX^{\delta})$ over G.

Representations of K_{11}

Series

$f = 0$

I	0
ξI	I
$\xi^2 I$	$-\xi I + A$

where A is a matrix of order n in a stander canonical form with respect to pseudolinear $(I + X^{-1}AX^{\delta})$ over G.

Corepresentations of K_{11}

Series

$$\widehat{f} = 0$$

I	$\xi I + \xi^2 A$

where A is a matrix of order n in a stander canonical form with respect to similarity $(X^{-1}AX)$ over F.

Corepresentations of K_{11}

$$\widehat{f} = 0$$

$$\left|\begin{array}{ccc|ccc} 1 & \xi & \xi^2 & 0 & 0 & 0 \\ 0 & 1 & -\xi & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & \xi & \xi^2 \end{array}\right|$$

Corepresentations of K_{11}

$$\widehat{f} = 3$$

$$\left[\begin{array}{ccc|ccc}
1 & \xi & \xi^2 & 0 & 0 & 0 \\
0 & 1 & -\xi & 1 & \xi & \xi^2
\end{array}\right]$$

$$\widehat{f} = 3$$

$$\left[\begin{array}{cccccc|ccc}
1 & 0 & \xi & 0 & \xi^2 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & \xi & 0 & \xi^2 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & -\xi & 0 & 1 & \xi & \xi^2 \\
0 & 0 & 0 & 1 & 0 & -\xi & 0 & 1 & -\xi
\end{array}\right]$$

$$\widehat{f} = 3$$

$$\left[\begin{array}{ccc|ccc}
1 & 0 & 0 & 0 & 0 & \xi \\
0 & 1 & 0 & 0 & \xi & 0 \\
0 & 0 & 1 & \xi & 0 & 0 \\
0 & 0 & 0 & 1 & \xi & \xi^2
\end{array}\right]$$

$$\widehat{f} = 3$$

$$\left[\begin{array}{ccc|cccccc}
1 & 0 & 0 & 0 & 0 & 0 & \xi & 0 & \xi \\
0 & 1 & 0 & 0 & \xi & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & \xi & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & \xi & 0 & \xi^2 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & \xi & 0 & \xi^2
\end{array}\right]$$

Corepresentations of K_{11}

$\widehat{f} = 1$

1	ξ	ξ^2

$\widehat{f} = 1$

1	ξ	ξ^2	0
0	1	$-\xi$	1

$\widehat{f} = 1$

1	ξ	ξ^2	0	0
0	1	$-\xi$	1	ξ

$\widehat{f} = 1$

1	ξ	0
0	1	ξ

$\widehat{f} = 1$

1	ξ	0	0
0	1	ξ	ξ^2

$\widehat{f} = 1$

1	0	0	ξ	0
0	1	ξ	0	0
0	0	1	ξ	ξ^2

Posible applications

- Application to representations of vector space categories (vectroids).
- Application to representations of artinian schurian right peak rings (PI rings).

I. Dorado, *Three-equipped posets and their representations and corepresentations (inseparable case)*. Linear Algebra and its Applications, Vol. **433**(2010), 1827-1850.

Thank you