Application

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2015-04361 **Skoglund, Mikael** **NT-14**

Information about applicant

Name: Mikael Skoglund

Doctorial degree: 1997-04-11

Birthdate: 19690114

Academic title: Professor

Gender: Male

Employer: Kungliga Tekniska högskolan

Administrating organisation: Kungliga Tekniska högskolan

Project site: Skolan för elektro- och systemteknik

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Descriptive data

Project info

Project title (Swedish)*

Informationsteoretiska metoder för nätverkad inferens

Project title (English)*

Information Theoretic Tools for Networked Inference

Abstract (English)*

Data are generated at rates and in amounts that were unheard of just a few years ago, and people lead increasingly connected lives. The vision for upcoming 5G communication systems points in the direction of 'everything connected' and we are presently at a breaking point where machines, vehicles, industrial systems and tools, and our societal infrastructures are beginning to form huge interconnected networks. There are multiple possible approaches to address the challenge of how to collect, store, transfer, communicate and analyze the massive amounts of data being produced. And in general, this is a cross-disciplinary problem, relying on several technologies and scientific areas. A very crude division into two layers of abstraction would be "data engineering" and "data analytics," where the former refers to problems related to the collection, storage and transportation of data, including aspects of the supporting infrastructure, networking and distributed computing. Issues relating to analytics are closer to the application layer in the traditional communication stack, and address how to draw conclusions, make decisions and act based on the data. Roughly speaking, the interface between data engineering and data analytics is software. There is however no clear definition of where the boundary between the two is, and any efficient system design in any case need relate to both areas jointly.

On the analytics side, one field that has been advocated in particular is statistical inference and its future development, to facilitate drawing valid conclusions from vast amounts of data, in a distributed and robust fashion. The terminology "distributed statistical inference" is quite well-established. In most of the existing work "distributed" then refers to the structure imposed by a particular network topology, enforcing certain causality and marginalization constraints. With the network modeled as a graph, communication constraints on the connections in the graph have often been of secondary importance, and information has been allowed to propagate between nodes without loss. In this proposal we will therefore use "networked inference" to mean "distributed inference with communication constraints." Our focus will be on novel ways of applying information theoretic tools to networked inference problems and also on investigating the deeper connection between the two areas, motivated by the cross-disciplinary nature of the massive data challenge. In particular, we advocate the importance of looking at aspects of communications, networks and information theory jointly with statistical inference to get new insight and develop novel tools. We will draw on our solid experience in information theory, as well as on our previous contributions to statistical signal processing and communications.

Popular scientific description (Swedish)*

Världen blir allt mer uppkopplad och vi har idag svårt att tänka oss en vardag utan mobil telefoni eller Internet. Medan kommunikationsnätverk tidigare användes främst för att överföra information från en person till en annan, så har vi under senare år sett en trend där även insamling av information från mätningar samordnas i nätverk. Sådana sensornätverk används redan inom allt från trafikövervakning till hälsovård. Kommunikationsnätverk används också alltmer för insamling, behandling och lagring av mycket stora mängder data; vi är på väg in i ett "Big-Data"-samhälle. Ett annat område som är på raskt intågande är återkopplad styrning över kommunikationsnätverk, speciellt trådlösa nätverk. Storskaliga reglersystem med data som kommuniceras över nätverk kommer i allt större utsträckning finnas i smarta elnät, intelligenta transportsystem och i processindustrin. Tjänster och applikationer som använder processer återkopplade över nätverk ställer dock mycket högre och annorlunda krav än personkommunikation och mobiltelefoni. Ytterligare en trend är att fler tjänster i framtiden kommer köras via den öppna allmänna kommunikationsinfrastrukturen, även för industriella tillämpningar. Detta medför ytterligare stora utmaningar när det gäller säkerhet och tillit; fortsatt utbyggnad av nya lösningar hindras i viss mån av en generell oro att kommunikationstekniken inte är tillräckligt säker och tillförlitlig. Det är alltså tydligt att nästan alla delar av vårt samhälle, vår industri och vårt dagliga liv kommer påverkas av kommunikation i nätverk, och i de flesta fall över ett framtida öppet super-Internet. Denna kommunikation och kopplingen via sensorer till den omgivande fysiska miljön kommer generera mycket stora mängder data. En viktig utmaning är att utveckla matematiska metoder och algoritmer för att dra giltiga slutsatser ur dessa data. Det är inte så rättframt att "mer data" enkelt medför "mer kunskap". Parallellt med utvecklingen av en infrastruktur som stöder insamling och transport av data måste vi därför adressera utmaningen i att effektivt generera kunskap och giltiga beslut ur mycket stora mängder data.

Den matematiska teoribildningen bakom digital kommunikation grundlades i allt väsentligt av Claude Shannon i två artiklar som han publicerade 1948. Den teori som Shannon utvecklade kom snabbt att kallas informationsteori, och sedan 1948 har Shannon själv och en lång och bred följd av andra framstående forskare gjort att teorin har framskridit. Denna utveckling har motiverats främst av samhällets behov av telekommunikation, men även ofta av ren nyfikenhet hos matematiker och matematiskt orienterade forskare inom fysik, elektroteknik och annan ingenjörsvetenskap. Praktiska genombrott har i flera fall kommit många år efter publicerandet av resultat som till en början tedde sig som rent akademiska. Kanske det mest framstående exemplet är felrättande kodning för trådlös kommunikation, där mycket effektiva lösningar förutsågs redan i Shannons artiklar men där praktiskt användbara algoritmer som arbetar nära den förutspådda effektiviteten såg dagens ljus först i slutet av 1990-talet.

Informationsteorin står nu inför flera stora utmaningar som motiveras av vårt allt mer uppkopplade samhälle. Det är sant att vi idag har till synes väl fungerande infrastruktur för trådlös mobilkommunikation och för uppkoppling mot Internet, men nästan all kommunikation som sker i dagens nät är fortfarande av typen "flytta information från ett ställe till ett annat". En infrastruktur som väl stöder industriell kommunikation, återkopplad reglering, och realtidsbehandling av stora datamängder kommer finnas tidigast i samband med 5e generationens trådlösa system, i början av 2020-talet. Men 5e generationens intågande kommer bara utgöra en början på ett sant uppkopplat samhälle, och nya möjligheter kommer föda nya idéer och tillämpningar som vi idag inte kan förutspå. Denna utveckling måste åtföljas av parallella genombrott inom matematisk modellering och nya verktyg för information, kommunikation och statistisk slutledning.

Målet med detta forskningsprojekt är att utveckla teorier och ingenjörsvetenskapliga metodiker för att stödja en framtida utveckling av det uppkopplade samhället. Vi fokuserar mot problem som anknyter till analys ur stora datamängder genererade och transporterade i nätverk, och vårt mål är att introducera informationsteoretiska verktyg att tillämpa inom sådan nätverkad statistisk inferens.

Project period

Number of project years*

4

Calculated project time*

2016-01-01 - 2019-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*	2. Teknik > 202. Elektroteknik och elektronik > 20204. Telekommunikation
	2. Teknik > 202. Elektroteknik och elektronik > 20205. Signalbehandling
	2. Teknik > 202. Elektroteknik och elektronik > 20299. Annan elektroteknik och elektronik

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Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

Information Theory

Keyword 2*

Statistical Inference

Keyword 3*

Networks

Keyword 4

Models

Keyword 5

Algorithms

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

Inga sådana överväganden är aktuella.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Research Plan

1 Purpose and Aims

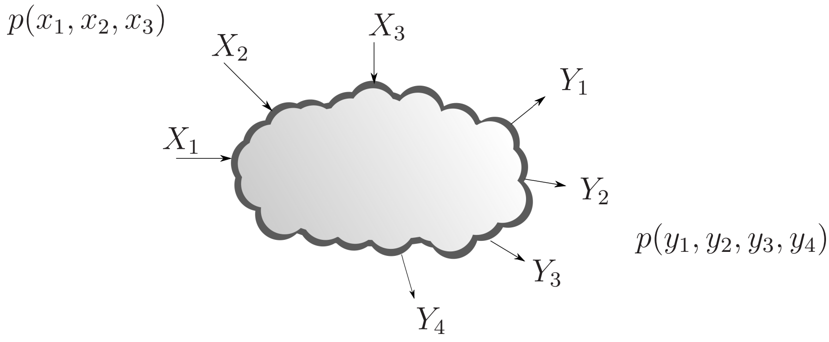
The revolutionary development in microelectronics over the past decades has led to inexpensive yet powerful devices that can communicate, sense, and act on the physical environment. Such devices together with our core communication and computing infrastructure enable a plethora of new applications at an unprecedented scale. Data are generated at rates and in amounts that were unheard of just a few years ago, and people lead increasingly connected lives. The vision for upcoming 5G communication systems points in the direction of 'everything connected' and we are presently at a breaking point where machines, vehicles, industrial systems and tools, and our societal infrastructures are beginning to form huge interconnected networks.

There are multiple possible approaches to address the challenge of how to collect, store, transfer, communicate and analyze the massive amounts of data being produced. And in general, this is a cross-disciplinary problem, relying on several technologies and scientific areas. A very crude division into two layers of abstraction would be "data engineering" and "data analytics," where the former refers to problems related to the collection, storage and transportation of data, including aspects of the supporting infrastructure, networking and distributed computing. Issues relating to analytics are closer to the application layer in the traditional communication stack, and address how to draw conclusions, make decisions and act based on the data. Roughly speaking, the interface between data engineering and data analytics is software. There is however no clear definition of where the boundary between the two is, and any efficient system design in any case need relate to both areas jointly.

On the analytics side, one field that has been advocated in particular is statistical inference and its future development, to facilitate drawing valid conclusions from vast amounts of data, in a distributed and robust fashion [1]. The terminology "distributed statistical inference" (distributed estimation, filtering, detection and decision) is quite well-established. In most of the existing work "distributed" refers to the structure imposed by a particular network topology, enforcing certain causality and marginalization constraints. With the network modeled as a graph, communication constraints on the connections in the graph have often been of secondary importance, and information has been allowed to propagate between nodes without loss. In this proposal we will therefore use "*networked* inference" to mean "distributed inference with communication constraints." Our focus will be on novel ways of applying information theoretic tools to networked inference problems and also on investigating the deeper connection between the two areas, motivated by the cross-disciplinary nature of the massive data challenge. In particular, we advocate the importance of looking at aspects of communication, networks and information theory jointly with statistical inference to get new insight and develop novel tools. We will draw on our solid experience in information theory, as well as on our previous contributions to statistical signal processing and communications.

2 Survey of the Field

As is well-known, the foundations for information theory were established by Claude Shannon in 1948. The theory was introduced as a tool for studying the communication of information between a sender and a receiver. Claude Shannon and others later expanded the field in various directions, and with applications also outside the core of digital communications. In 1998, fifty years after Shannon's first papers, the state of the theory was summarized in [2]. One major focus in the field during the past 15–20 years has been on sorting out the theoretical foundations for wireless communications and networking. Recent progress has also been made on establishing a relatively complete and general network information theory [3]. The main remaining challenge in the study of networks is the problem of scale; state-of-the art models, including those suggested in the past couple of years following [3], do not provide a satisfactory framework for large-scale and dynamic networks. Furthermore, from the mid first decade of the twenty-first century, the invention of compressed sensing [4] sparked a huge amount of new activities, ranging from algorithm development, via characterization of fundamental bounds [5] to applications.



In general, information theory is gradually shifting from a focus on wireless communications and systems to more general problem settings involving networking of information. Obviously there is also a long standing and tight connection between information theory and statistical inference [6]. However, relatively few in the information theory community have so far set out to explore the deeper connections. In the following paragraphs we introduce in some more detail the main background topics needed for the discussion of new proposed work in Sec. 3.

Information-theoretic coordination. The coordination problem in information theory was introduced in [7]. Consider the scenario illustrated above. Random variables X_1 to X_3 governed by the joint distribution $p(x_1, x_2, x_3)$ are fed into a network. Internal nodes in the network collect incoming data and forward, in a possibly non-linear and random fashion, outgoing data to other nodes. The random inputs and the internal communications result in the output variables Y_1 to Y_4. Given the input distribution $p(x_1, x_2, x_3)$ and the network topology, with rate-constrained communication between nodes, at known and fixed rates, the fundamental question asked is then: which output distributions $p(y_1, \ldots, y_4)$ can be generated? This problem is not solved in general, although [7] presented solutions to several special cases. While we have contributed to tightly related problems, e.g. in [8, 9], we will in the present project be interested in how the coordination problem over a network can be used to study the achievable performance of an application run on the network where, as described in Sec. 3.1, we will focus on distributed inference.

Coding for networked inference. Most existing results in network information theory are special cases of the general (multi-hop) memoryless noisy network [3]. In this setup, only nodes on the edge of the network send and receive information, and internal nodes are passively relaying (forwarding or re-coding) the received information. Modern applications call for extensions to this scenario, allowing internal nodes to perform more general operations, e.g. storing information and performing computations. The concept that unifies distributed storage and in-network computations is that of network coding [10–13]. While network coding is generally understood as a linear coding technique, we have looked deeply into the relation between linear and non-linear computations in [13]. Networked data analytics subject to storage and bandwidth constraints crucially rely on efficient storage and compression. Network coding was applied to increase the efficiency and robustness of distributed storage systems in, e.g., [11, 12]. The existing work on distributed source coding and compression is quite extensive, however only few works have considered the relation between inference and compression [14].

Networked sensing and analytics. The invention of compressed sensing [4] has been a major inspiration for related work during the past decade. However, so far relatively little has been done to extend the basic concepts to the distributed setting, or to take communication and bandwidth constraints into account. Exceptions include our own work in [15, 16]. Also, most of the development in the field has relied on tools from statistics, signal processing and optimization, and relatively few contributions have concerned the information theoretic foundations, with exceptions in, e.g., [5, 17, 18].

Feedback, interaction and geometry of information. In networks with feedback from nodes that are receiving to nodes that transmit, Massey's directed information in general provides the relevant quantification of information flow. Our own contributions to the interpretation and use of directed information includes connecting the amount of directed information flowing in the network to achievability of stabilization of a linear system over the network [19]. Another recent concept that connects to feedback in networks is that of interaction, e.g. [20]; close connections between stochastic control and interactive communications were identified in [21]. Yet another recent concept is that of action, and action-dependent states and side-information [22, 23].

In many networked problems there are also even more sophisticated directionality and feedback concepts that have not been investigated to a satisfactory maturity. This goes in particular for settings where the direction of the information flow is important not only because of causality and feedback constraints, but also due to inherent asymmetries in the problem formulation. To address this statement in some more detail, consider the traditional (Kolmogorov) construction of a probability space. The approach relies on a class of measurable sets (forming a σ-algebra) and a set-function (the probability measure) defined on that class. Since a construction based on sets and classes of sets does not allow a definition of "direction" there are several important problems in information theory, signal processing and control that cannot be properly modeled. To be more specific, note that in the traditional construction, the standard way of discussing direction and causality is based on conditional probability. However, in this model there is no way of enforcing underlying directionalities. For example, if three variables form a Markov chain $X \to Y \to Z$ then $Z \to Y \to X$ is also a Markov chain, and you cannot tell whether X causes Z or Z causes X, even if this can be very clear from knowing which practical setup is being modeled. In contrast, the approach to probability used in quantum mechanics defines probability over a vector space (a Hilbert space), allowing for more direct modeling of directionality and other geometrical aspects. While there is a clear need for a framework that can capture directionality, an approach based on quantum mechanical probability has so far not been applied to information theory and related fields, and surprisingly few are advocating the approach, at all, outside quantum physics and quantum information. An exception is [24] where quantum-like constructions are suggested for more general use in, e.g., social science and finance (see [24] for a definition of 'quantum-like'). As discussed in [24], quantum-like models also allow for defining probabilities relative to a certain context, in ways that the traditional approach cannot support.

While quantum-like modeling has so far not been used in mainstream information theory and statistics, there is other recent work that introduces geometrical aspects, however still based on an underlying Kolmogorov approach to probability. In particular, the theory of information geometry has found useful applications and allowed for new interpretations of classical results [25–28].

Network approximations, deterministic modeling As mentioned, one remaining major challenge in network information theory is to develop models that scale gracefully as the size of the network increases. One promising approach are deterministic models that can be used as a tool to approximate the capacity of large Gaussian networks [29–31]. Another related technique relies on partitioning the overall network into smaller sub-structures for which the capacity can be determined, and then use the collection of the sub-parts to derive approximate inner and outer bounds [32].

In [29–31] deterministic models were formulated to approximate random network models, in particular Gaussian noise models. While information theory and statistical inference require an underlying random model, control theory often approaches related problems based on deterministic models, in particular when robustness to unforeseen disturbances and model variations is the goal. The recent paper by Nair [33] introduced a non-stochastic framework for information theory and estimation, inspired by robust control.

3 Work Description and Preliminary Results

In this part we outline new proposed work, relating it to our preliminary results. Our suggested activities are sorted in four different areas. Naturally, these overlap and some of the more important problems involve aspects from several of them.

3.1 Coordination and Inference

As mentioned, coordination is the problem of characterizing the class of joint distributions that can be generated over a network. Obviously there is a connection between this set and the class of possible inference algorithms and their performance that can be implemented in the network; any inference problem is ultimately characterized by a joint distribution on the data, observables and estimates. Surprisingly, the deeper connections between information theoretic coordination and statistical inference have so far not been explored.

To illustrate the basic concepts, let T_{x^n} denote the type of sequence $x^n = (x_1, \ldots, x_n)$, that is

$$T_{x^n}(a) = \frac{1}{n} \sum_{i=1}^{n} \mathbb{1}(x_i = a)$$

(where $\mathbb{1}(A) = 1$ if A is true, and zero o.w.). Consider a random sequence $\{X_i\}$ with $X_i \in \mathcal{X}$, $|\mathcal{X}| < \infty$, and with samples generated i.i.d. $\sim P_\theta$. Then it can be verified that

$$\Pr(X^n = x^n) = 2^{-n(H(T_{x^n})+D(T_{x^n}\|P_\theta))}$$

(where $H(\cdot)$ denotes entropy, and $D(\cdot\|\cdot)$ relative entropy, or divergence). That is, the type T_{X^n} is a sufficient statistic, and, for example, ML estimation based on the observation $X^n = x^n$ reduces to

$$\hat{\theta}_{\text{ML}} = \operatorname*{argmin}_{\theta} D(T_{x^n}\|P_\theta),$$

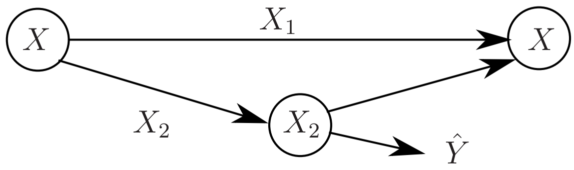
which makes intuitive sense: choose θ so that P_θ is as close as possible to the observed type, in the sense of $D(\cdot\|\cdot)$. The observation that T_{x^n} forms a sufficient statistic is not new [6], even though it is perhaps not widely known, and surely not regularly used as a basis for building statistical tools. However, the reflection that the concept of type provides an interface for inference over networks with finite link capacities, and therefore finite variable alphabets, has not been made explicit before. This latter observation is crucial for us, since “weak coordination” as defined in [7] concerns the characterization of the class of possible joint types of the variables in the network. Hence we can connect statistical inference and coordination via type as the interface; this is to our knowledge a novel suggestion. We will explore this further, and we will use the tools of coordination to characterize the possible inference performance over specific network typologies.

In our preliminary work [9] we looked at communication performance subject to a constraint on the interference caused at a node who is not the intended user. Interpreting this node instead as a potential eavesdropper, we will also consider communication with inference privacy. Namely, based on our observed connection between type and inference performance, the constraint on the received type at the eavesdropper can be turned into one concerning instead the possible information leakage in the sense of which statistical conclusions can be drawn.

While the concept of type applies to finite (or countable) alphabets, it does not have a natural extension to uncountable sets. However, in the case of the Borel subsets of $\mathbb{R}^k$, we can use a quantizer to approximate any absolutely continuous distribution as a simple function, with a finite output set. The connection to coordination we need is then provided via the very recent work [34], on output distribution constrained quantization.

3.2 Coding for Networked Inference

Relatively few have looked at coding and compression for networked inference, even though some important previous results were summarized in [14]. However, work on inference with storage constraints is basically non-existent. We will therefore strive to consider the two aspects jointly, and contribute to networked inference with both communication and storage constraints. One important direction will be network coding for storage, as in [11, 12], jointly with compression mechanisms inspired by the techniques in [14]. While the codes in [11, 12] are designed to handle node/storage failures, they cannot counteract link failures/errors. We will therefore also look at scenarios with noisy connections between nodes, calling for error correction capabilities. However, with inference performance as the overall design criterion it is not clear what optimality conditions should be placed on the underlying network code. Subject to a bandwidth–performance tradeoff, it may, for example, be suboptimal to strive for error-free link performance. That is, when coding jointly for compression, error-protection, storage and inference performance, it may be better to allow some residual errors inside the network to leave redundancy for, e.g., improved robustness to storage failures.



Another interesting tradeoff is illustrated above, as a very simple example. Assume that the full data X are coded such that both representations X_1 and X_2 are needed to reproduce X exactly. The message X_2 is stored as illustrated. Assume that X is also related to another, hidden, variable Y, and that there is a need to estimate Y at the node storing X_2. Now, with limited storage at this node, how should the representations X_1 and X_2 be formed such that X can be reproduced, and such that $\hat{Y}(X_2)$ is a good estimate of Y? Of course, a more interesting scenario involves many nodes, many variables, and several tradeoffs between competing goals. Taking into account also that links between nodes may introduce errors, it is clear that there is an interesting and challenging overall tradeoff between coding for error protection, compression, storage and estimation.

3.3 Deterministic Models

As mentioned, while network information theory is a mature area [3], one remaining challenge is to formulate models that scale gracefully as the size of the network grows. These models should also be easy to update and modify to make them useful in dynamic settings. The main approaches so far are deterministic models [29–31] and bounding models [32]. In this project we will focus on deterministic modeling, and we will in particular strive to wed deterministic network modeling with the non-stochastic framework introduced in [33]. Besides the new approach itself, the main contribution in [33] was to formulate basic information theoretic concepts on the new non-stochastic foundation. We will use this framework and look deep into the connection to deterministic network modeling. The paper [33] also presented some basic result on linear system state estimation in noise. We will expand on these and formulate more general problems, including non-linear ones. Since one main use for the models in [33] is to capture robustness, e.g. to unforeseen disturbances, we will also look at aspects of security and privacy. Connecting to the problem outlined in Sec. 3.1, we will for example study robustness toward an unwanted eavesdropper who tries to conclude underlying parameters in the system setup. Here robustness can, e.g., refer to guaranteed deterministic resilience to all members in a class of available inference schemes.

3.4 Distributed Data Analytics and Sensing

Compressed sensing has been a very active area in the past several years. We have worked on quantization [16] and on distributed sensing [15]. We have also contributed to fundamental algorithmic aspects [35] and information-theoretic performance bounds [18]. Although some work relating to a distributed setting exists, including ours in [15], networked compressed sensing (with communication constraints) is a much less mature area. We will use the tools in [18] to approach networked problems based, e.g., on [15]. Another interesting direction is to combine distributed compressed sensing with the activities proposed in Sec. 3.2, based on network coding.

High-dimensional data $x^k \in \mathbb{R}^k$ can always be mapped to a low-dimensional representation $y^\ell \in \mathbb{R}^\ell$, $1 \leq \ell \ll k$, and back again, without loss. However, in general the corresponding mappings will be highly discontinuous. Compressed sensing enforces linear sampling $\mathbb{R}^k \to \mathbb{R}^\ell$ and allows for non-linear reconstruction $\mathbb{R}^\ell \to \mathbb{R}^k$, and as detailed in [4] this can also happen without loss, under certain conditions. However, linear sampling together with linear reconstruction will always introduce irreversible losses. One can also consider intermediate scenarios in between linear-to-linear, compressed sensing, and the fully general case, by enforcing various smoothness conditions on the allowed mappings. This latter idea was studied using information theoretic tools in [5]. Moving to a distributed/networked setting, there are interesting tradeoffs that were not investigated in [5]. It will, for example, be interesting to put different constraints on local mappings (nodes in the network) and the overall mapping resulting from a distributed solution. In [5] it was shown that there is asymptotically no loss in enforcing continuous mappings in the limit as both k and ℓ grow, with fixed $r = \ell/k$. Based on this result, a more specific question in the distributed case is asking what can be achieved if local mappings are selected as continuous and finite-dimensional, but the number of nodes in the network grows. We will study this and related problems for networked compressed sensing, and generalizations.

3.5 Feedback, Interaction and Direction

The dual role of feedback is well-known to researchers in stochastic control [36, 37], and already Shannon studied the effect of feedback on communication. The fact that feedback does not improve capacity of memoryless channels is often misinterpreted to mean that feedback does not affect communication performance. However, as demonstrated in the classic work [38] feedback can improve the error probability versus block length performance quite drastically, even by an order of magnitude. Our paper [19] was the first to introduce schemes inspired by [38] to a scenario of closed-loop control over Gaussian networks. One important conclusion that was drawn in our work is that linear estimation and feedback control based on linear Kalman filtering, is in general not optimal even in problems where all variables are jointly Gaussian [19, 39].

Our first planned effort in this part relates to the coordination problem. Namely, we will investigate what happens when the state of the network, as defined by the joint distribution of network variables, is allowed to change as a result of causal feedback. Introducing time-variation also via a dynamic model for the input distribution to the network, we will look at general linear and non-linear inference on underlying parameters and hidden system/network states, based on the output variables. One promising direction relies on our results in [19], with extensions to general (non-Gaussian) networks. In particular we will again be interested in using type as the interface between observations and inference. We will look at both open-loop estimation/filtering, and closed-loop control based on type as the sufficient statistic. We also believe that posterior matching [20] will be a useful tool in this overall problem setting, as well as the concept of action-dependent state/side-information [22, 23]. Relating to feedback and action, we in addition have problems involving multiple rounds of interaction in a causal manner. Consider, for example, a setting where two agents in a network communicate interactively toward a common (inference) goal. We will build on our existing results to study multiple-round problems, and in particular we will strive to characterize the minimum number of iterations needed to reach a certain performance goal. Our "two-stage coding condition" in [23] and our results on iterated guessing in [40] are tools in this direction.

As discussed in Sec. 2, another important area when considering general notions of feedback, interaction and directionality is quantum-like modeling. We will investigate directed information in graphs and related structures, and we will pursue significant extensions of modern concept like those in [24] to such information theoretic notions as information flow, conditional directed information, and conditional mutual information, in general networks with feedback loops and causality constraints. As in other parts of the project, we will in particular be interested in inference as the application running on the network.

3.6 New Tools and Models

In classical point estimation, the standard approach to characterizing asymptotic estimator efficiency is to relate to the Cramér–Rao bound. Similarly, in Bayesian estimation/detection and information theory the Fano inequality is a crucial tool. Recent progress on generalizing the Fano approach to problems with a continuous parameter set was reported in [41]. Furthermore, bounds that are in general tighter than the Fano inequality have been developed recently in the context of finite block-length coding [42]. Based on this recent progress, one planned effort is to borrow these tools from information theory and apply them to bounding the efficiency of networked inference with constraints, e.g. on the number of observations.

In Sec. 3.1 we saw that the type T_{x^n} is a sufficient statistic, and that inference on a parameter θ can be based on minimizing the distance $D(T_{x^n} \| P_\theta)$. However, $D(\cdot\|\cdot)$ is not a "distance" in the sense of a metric, making it hard to use geometrical intuition to get insight. One approach to get around this drawback are the tools offered by information geometry [25–27]. To illustrate the basic approach, consider a probability mass function P which is close to another distribution Q in the sense that $P = Q(1+\varepsilon L)$ for $\varepsilon > 0$ and for an L such that $\sum QL = 0$. Then it holds that

$$D(P\|Q) = \frac{1}{2}\varepsilon^2 \|L\|_Q^2 + o(\varepsilon^2)$$

where $\|L\|_Q^2 = \sum L^2 Q$. Hence, relative entropy behaves locally as a weighted squared distance. Building on this simple but important observation, a complete geometric framework can be formulated [26]. (See also [43] and the very recent [44] for a slightly different approach to the geometry of relative entropy and related notions.) The results in [25–27] have so far been employed to get further insight into some of the basic network information theory problems, e.g., the capacity region of the general broadcast channel [27]. However, with the very recent work [28] as an exception, the tools developed in [26, 27] have not been used to study problems of statistical inference. Also, the fundamental importance of relative entropy when using type as a sufficient statistic has to our knowledge not been noticed in this context before. We will therefore use information geometry to get deeper insight into networked inference in general, and the interplay between coordination and inference (Sec. 3.1) in particular. Furthermore, we will explore the local linearization approach proposed in [27, 45] in connection to linear deterministic network modeling, as discussed in Sec. 3.3. Finally, we will also research what connections we can find between the information geometry approach and quantum-like modeling, inspired by [24].

Another kind of geometric insight (in topological measurable spaces) is based on the information dimension [5]. Although this notion is more abstract and not Euclidean as in [26, 27] we believe that there are connections with information geometry and possibly also models based on [24], and as a higher-risk side-activity we will explore this hypothesis further.

3.7 Work Breakdown

Our goal is to engage two PhD students and one postdoc to pursue the research outlined here, with the applicant as co-worker and adviser. A rough plan is as follows.

- PhD student 1 (PhD1): Will focus on the interplay between coordination and networked inference. We will first pursue the basic connections outlined in Sec. 3.1. The student will then also interact with PhD2 to look at deterministic modeling for robust coordination as suggested in Sec. 3.3. PhD1 will in addition work with PD to look at feedback for coordination, as well as the geometrical aspects of coordination and networked inference, as suggested in Sec. 3.5 and Sec. 3.6.

- PhD student 2 (PhD2): Will focus on coding for inference and storage (Sec. 3.2), deterministic modeling (Sec. 3.3) and distributed analytics (Sec. 3.4). PhD2 will also work with PD to investigate geometrical aspects of distributed compressed sensing and deterministic modeling, as suggested in Sec. 3.4 and Sec. 3.6.

- PostDoc (PD): Will specialize on feedback and interaction (Sec. 3.5) and the new tools suggested in Sec. 3.6. He/she will also interact with both PhD students, as outlined.

We see the work proposed in Sec. 3.5 and Sec. 3.6 as the higher-risk part of the project. Still with collaboration as suggested, and also with serious involvement by the applicant, we believe that there is ample opportunity for rewarding progress.

Bibliography

[1] M. Jordan et al., *Frontiers in massive data analysis*, The National Academies Press, 2013.

[2] Verdu et al., guest editors, "Fifty years of information theory," *IEEE Trans. Inf. Theory*, , no. 6, 1998, special issue.

[3] A. El Gamal and Y-H. Kim, *Network information theory*, Cambridge University Press, 2011.

[4] D.L. Donoho, "Compressed sensing," *IEEE Transactions on Information Theory*, vol. 52, no. 4, pp. 1289–1306, April 2006.

[5] Y. Wu and S. Verdu, "Renyi information dimension: Fundamental limits of almost lossless analog compression," *IEEE Trans. Inf. Theory*, vol. 56, no. 8, pp. 3721–3748, Aug 2010.

[6] I. Csiszár and P. C. Shields, "Information theory and statistics: A tutorial," *Foundations and Trends in Communications and Information Theory*, vol. 1, no. 4, pp. 417–528, 2004.

[7] P. Cuff, H. Permuter, and T. Cover, "Coordination capacity," *IEEE Trans. Inf. Theory*, Sept. 2010.

[8] R. Blasco Serrano, R. Thobaben, and M. Skoglund, "Polar codes for coordination in cascade networks," in *Proc. Int. Zurich Seminar on Comms.*, Feb. 2012.

[9] R. Blasco Serrano, R. Thobaben, and M. Skoglund, "Communication and interference coordination," in *Proc. IEEE ITW (invited paper)*, 2014.

[10] M. Xiao and M. Skoglund, "Multiple-user cooperative communications based on linear network coding," *IEEE Trans. Commun.*, vol. 58, no. 11, Nov. 2010.

[11] A. G. Dimakis, P. B. Godfrey, Y. Wu, M. J. Wainwright, and K. Ramchandran, "Network coding for distributed storage systems," *IEEE Trans. Inf. Theory*, vol. 56, no. 9, pp. 4539–4551, Sept. 2010.

[12] M. Gerami, M. Xiao, and M. Skoglund, "Optimal-cost repair in multi-hop distributed storage systems," in *Proc. IEEE ISIT*, 2011.

[13] S. Huang and M. Skoglund, "On linear coding over finite rings and applications to computing," *IEEE Trans. Inf. Theory*, submitted Oct. 12, revised Sep. 13.

[14] T. S. Han and S.-I. Amari, "Statistical inference under multiterminal data compression," *IEEE Trans. Inf. Theory*, vol. 44, no. 6, pp. 2300–2324, Oct 1998.

[15] D. Sundman, S. Chatterjee, and M. Skoglund, "Distributed greedy pursuit algorithms," *Signal Processing*, vol. 105, no. 12, pp. 298–315, Dec. 2014.

[16] A. Shirazinia, S. Chatterjee, and M. Skoglund, "Analysis-by-synthesis quantization for compressed sensing measurements," *IEEE Trans. Signal. Proc.*, vol. 61, no. 22, pp. 5789–5800, Nov 2013.

[17] S. Aeron, V. Saligrama, and Z. Manqi, "Information theoretic bounds for compressed sensing," *IEEE Trans. Inf. Theory*, vol. 56, no. 10, pp. 5111–5130, Oct 2010.

[18] R. Blasco Serrano, D. Zachariah, D. Sundman, M. Skoglund, and R. Thobaben, "A measurement rate-MSE tradeoff for compressive sensing through partial support recovery," *IEEE Trans. Signal. Proc.*, vol. 62, no. 18, pp. 4643–4658, Sept. 2014.

[19] A. Zaidi, S. Yüksel, T. Oechtering, and M. Skoglund, "Stabilization of linear systems over Gaussian networks," *IEEE Trans. Aut. Control*, pp. 2369–2384, Sept. 2014.

[20] O. Shayevitz and M. Feder, "Optimal feedback communication via posterior matching," *IEEE Trans. Inf. Theory*, Mar. 2011.

[21] T. P. Coleman, "A stochastic control viewpoint on 'posterior matching'-style feedback communication schemes.," in *IEEE ISIT*, 2009.

[22] T. Weissman, "Capacity of channels with action-dependent states," *IEEE Trans. Inf. Theory*, vol. 56, no. 11, pp. 5396–5411, Nov 2010.

[23] K. Kittichokechai, T. J. Oechtering, and M. Skoglund, "Coding with action-dependent side information and additional reconstruction requirements," *IEEE Trans. Inf. Theory*, to appear. (arxiv.org/pdf/1202.1484).

[24] A. Y. Khrennikov, *Ubiquitous Quantum Structure: From Psychology to Finance*, Springer, 2010.

[25] S. i Amari and H. Nagaoka, *Methods of Information Geometry*, Americal Math. Soc., 2007.

[26] E. Abbe, *Local to global geometric methods in information theory*, Ph.D. thesis, MIT, 2008.

[27] S.-L. Huang, *Eucledian network information theory*, Ph.D. thesis, MIT, 2013.

[28] K.-C. Chen, S.-L. Huang, L. Zheng, and H. V. Poor, “Communication theoretic data analytics,” *arXiv:1501.05379 [cs.IT]*, 2015.

[29] A. S. Avestimehr, S. N. Diggavi, and D. N. C. Tse, “Wireless network information flow: A deterministic approach,” *IEEE Transactions on Information Theory*, vol. 57, no. 4, pp. 1872–1905, Apr. 2011.

[30] N. Schrammar and M. Skoglund, “Transmission strategies for wireless relay networks obtained from linear finite-field deterministic models,” *IEEE Trans. Commun.*, Aug. 2012.

[31] N. Schrammar and M. Skoglund, “Approximate secrecy capacity of a class of Gaussian relay networks,” *IEEE Trans. Inf. Theory*, Apr 2013, submitted.

[32] J. Du, M. Medard, M. Xiao, and M. Skoglund, “Scalable capacity bounding models for wireless networks.,” *IEEE Trans. Inf. Theory*, 2014, submitted. arXiv:1401.4189.

[33] G. Nair, “A nonstochastic information theory for communication and state estimation,” *IEEE Trans. Aut. Control*, vol. 58, no. 6, pp. 1497–1510, June 2013.

[34] N. Saldi, T. Linder, and S. Yüksel, “Randomized quantization and source coding with constrained output distribution,” *IEEE Trans. Inf. Theory*, vol. 61, no. 1, pp. 91–106, Jan 2015.

[35] S. Chatterjee, D. Sundman, M. Vekhaperä, and M. Skoglund, “Projection and look ahead based strategies for atom selection,” *IEEE Trans. Signal. Proc.*, vol. 60, no. 2, Feb. 2012.

[36] W. Wonham, “On the separation theorem of stochastic control,” *SIAM J. Control*, vol. 6, no. 2, pp. 659–676, 1968.

[37] S. Yüksel and T. Başar, *Stochastic Networked Control Systems*, Birkhäuser, 2013.

[38] J. Schalkwijk and T. Kailath, “A coding scheme for additive noise channels with feedback,” *IEEE Transactions on Information Theory*, vol. 12, no. 2, pp. 172–182, Apr 1966.

[39] A. Zaidi, S. Yüksel, T. Oechtering, and M. Skoglund, “On optimal policies for control and estimation over Gaussian relay channels,” *Automatica*, vol. 49, pp. 2892–2897, Sept. 2013.

[40] F. Naghibi, T. Oechtering, and M. Skoglund, “Authentication with a guessing adversary,” submitted Jan. 15.

[41] J. C. Duchi and M. J. Wainwright, “Distance-based and continuum Fano inequalities with applications to statistical estimation,” *arXiv:1311.2669 [cs.IT]*, Nov. 2013.

[42] Y. Polyanskiy, H. V. Poor, and S. Verdú, “Channel coding rate in the finite blocklength regime,” *IEEE Trans. Inf. Theory*, May 2010.

[43] B. Fuglede and F. Topsoe, “Jensen–Shannon divergence and Hilbert space embedding,” in *Proc. IEEE ISIT*, June 2004, p. 31.

[44] A. Abdullah et al., “Sketching, embedding, and dimensionality reduction for information spaces,” *arXiv:1503.05225*, Mar. 2015.

[45] S.-L. Huang and L. Zheng, “Linear information coupling problems,” in *Proc. IEEE ISIT*, July 2012, pp. 1029–1033.

4 Significance and Impact

For more than a century Sweden has been at the forefront of complex systems design, as is evident by successful export industry and internationally recognized research, but Swedish industry is now under pressure by competition from rapidly growing economies. To stay competitive, it is imperative for Sweden to continue to educate engineers and scientists in the general area of information systems. Our graduates need to receive training at the highest international level, and they need to know about complex interaction in large systems, scientific and mathematical modeling, and how to focus on relevant sub-problems. One problem domain that is attracting steadily increasing attention is ’BigData’ and data analytics. The area is gaining in importance also for traditional systems industry, in Sweden with Ericsson as the foremost example. One important goal with the proposed project is to train PhD’s and postdocs in the general area of information, networks and inference, with a focus on the crucially important intersection between these areas. Our activities will also influence the more basic training at the levels of BSc and MSc.

The applicant has built a quite sizable environment at KTH focusing on information theory and its applications, as well as related fields. As of March 2015 Skoglund has been the main or co-supervisor for 25 graduated PhD students, and 13 postdocs. The present affiliations of graduated PhD's include Ericsson Research (Stockholm and Gothenburg), Tobii (Stockholm), Google (Stockholm), Huawei (Stockholm), Huawei Mathematics and Algorithms Lab (Paris), Silver Atena Electronic Systems (Hamburg), PII Pipeline Solutions (Mannheim), UBS Investment Bank (Manhattan), MIT, Chalmers Univ., TU Berlin, Uppsala Univ., Beijing Univ. Post Telecom, and Shanghai Research Center for Wireless Comms. Present affiliations of former postdocs include the faculty at KTH, Ericsson (Gothenburg), Huawei (Stockholm), Nvidia (UK), Aalto Univ. (Finland), City Univ. Hong Kong and Tongji Univ. (Shanghai). We claim that the best prediction of future impact and significance is to relate to this constant flow of graduated PhD's and postdocs that leave KTH to interact with industry, society and other academic institutions.

Our achievements will be reported at top-ranked international conferences and published in the most prestigious journals in our field, creating visibility and the interest of other parties in contributing to further developments. Our results will also be disseminated to all relevant stakeholders, in particular Ericsson with which KTH has recently signed a mutual MoU for enhanced collaboration; the applicant is coordinating this effort at KTH. Finally, we also have as a goal to write a book/monograph on information theory for networked inference, partially based on our results in this project.

5 Collaboration

The applicant is with the ACCESS Linnaeus Center at KTH, a leading European university environment in the area of information networking and systems and an excellent forum for cross-disciplinary work in the field. The applicant also has extensive experience from collaborating in larger (framework) projects, including the VR ICT framework programs CLONES (PI), Trust Wireless (PI), and Scaling up MIMO (co-PI); the VINNOVA ICT framework program NECS (co-PI); the SSF framework program RAMCOORAN (PI); the ERC advanced grant AMIMOS (co-PI); the EU Fp6–7 IP's WINNER and METIS, and the EU Fp7 STREP's FeedNetBack, SENDORA and QUASAR. The applicant is also involved in the EU/EIT ICT Labs activities, and in the Swedish government Strategic Research Area supported environment TNG centered at KTH and with SU, Acreo and SICS as partners; the applicant is on the steering committee for TNG.

Skoglund has a long history of international cooperation and exchange, and he has an unusually wide collaboration network. As one quantifier, we note that joint papers have been published with distinguished members of the faculty at Harvard, MIT, Stanford, Princeton, Purdue, Tufts, Univ. New Mexico, Oregon State Univ., Univ. Southern California (USA); Univ. Toronto, Queens Univ. (Canada); Taiwan Nat. Chiao-Tung Univ., Tokyo Inst. Tech., Tsinghua, City Univ. Hong Kong, Singapore Nat. inst. infocomm research, IISc, Sharif, Technion (Middle-east, Asia); Aalto Univ., TU Munich, TU Dresden, NTNU Trondheim (Europe).

6 Other External Funding

The only other funding relevant with reference to the proposed research project is:

- The ACCESS Linnaeus Center, funded by VR until mid-2016.
- The applicant's VR ICT framework program 'CLONES' with a total budget of 9 000 kSEK for 2015–18. That project is however a collaboration with other groups at KTH, and less than 25% of the budget is available to the applicant and his group. Also, thematically there is almost no overlap between CLONES and the presently proposed project. Although problems related to networked control and security are relevant to both projects, those topics are central to CLONES but only examples of applications for the methods we will develop in the new project. Moreover the focus in CLONES is considerably narrower, on a certain kind of networked systems, and also with a cross-layer perspective that is not reflected in the present proposal.
- The applicant has also applied for a VR 'rådsprofessors'-program, in the February 2015 call. To our understanding, if that is granted the present project will be considered part of it.

Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

Short status report for the ongoing project:
Noisy Networks, 621-2011-5854, 820 kkr per year, 2012–15

From the 'Purpose and Aims' section of the original proposal, we cite:
We propose to study theoretical aspects of networked digital communications. We will focus on information-theoretic considerations, to investigate both new fundamental theoretical results and also propose designs and guidelines inspired by these results. The suggested research is motivated by wireless sensor and ad-hoc networking, and by future cellular wireless systems with advanced cooperation between cells (relaying and coordinated multi-point transmission). However the principles we study are general and will find applications also in related fields, in particular in the evolution of the (wired and wireless) Internet.

Results so far

Selected journal papers, published and in review, that present work fully or partially supported by the project are listed at the end of the report.

Network information theory
Our contributions to network information theory, so far in the project, are presented in [1,2,4,12,14,15,16,17,18,20]. This line of work has followed the original project proposal relatively closely. We proposed, for example, to work on relaying for communication in networks, and papers that represent this topic include [1,2,3,12,16]. As another example, we also suggested to work on action-dependent states and side-information, and work in this direction is presented in [14,20].

Coding for noisy networks
Work on the design and analysis of new coding schemes includes [5,6,15]. Also this line of work more-or-less follows the original plan. For example, we suggested to work on code design for relaying, as in [5,6].

Theory for wireless communications
In the original plan, we divided the proposed work as 'wireless networks' and 'general networks.' Our results that focus on the wireless scenario are presented in [2,3,10,13,16,19]. Topics we suggested include relaying as in [2], bounds based on degrees-of-freedom analysis as presented in [16], transmission schemes for interference channels [13], and capacity bounds [19].

Sensing, filtering and stabilization over networks
Wireless sensor and actuation networks were mentioned as one important area of application. However, contributions in this direction were not at the center of our focus in the project plan. Our other activities however inspired also efforts in this direction, with results presented in [7,8,11]. This line of work forms an important connection between the previous project and the one proposed in the present submission.

Mathematical foundations
Our activities on network information theory also sparked an effort where we investigated the very foundations of the modeling of sources with general memory [9].

The Ph.D. students Zhongwei Si, Dennis Sundman, Ali Zaidi, and Hieu Do were supported in part by the project, and have now graduated.

Relation to present proposal
The presently proposed project relies on the previous one in the sense that the experience gained and tools learned are crucial also for the new project. However the new suggested efforts are not a direct continuation. Although noisy networks and networked communications are important in both cases, the previous project had communication performance, e.g. in terms of capacity and degrees-of-freedom, as the main design objective, while the new project focuses on networked inference. We estimate that the PhD students who are still active in the previous project will graduate in late 2015 or early 2016, and we therefore do not anticipate that present students will engage also in the new project.

Resources in total
In our comments to the original suggested budget for the previous project, we stated that four Ph.D. students will be partially funded by the VR grant. While we received less funding than asked for from VR, we were still able to reach critical mass, by using co-funding from KTH faculty funding and from the ACCESS Linnaeus center. Hieu Do also contributed part of his time to an SSF framework grant. The students we engaged were in addition not supported simultaneously by VR. For example, Z. Si graduated in Jan. 2013, and we then moved D. Sundman to the project. We estimate that on average two full-time equivalent students have contributed simultaneously, at a total annual cost of about 1 500 kkr. The 820 kkr/year received from VR has thus supported roughly 55% of the overall cost for students. KTH faculty funds for research, research education anhave contributed another 30% and funds received from VR via the ACCESS Linnaeus Center the remaining 15%.

Journal Papers (published/accepted)
[1] T. Oechtering and M. Skoglund, “Bidirectional broadcast channel with random states non-causally known at the encoder,” *IEEE Trans. Inform. Theory*, January 2013.
[2] S. Yao, T. Kim, M. Skoglund and H. V. Poor, “Half-duplex relaying over slow fading channels based on quantize-and-forward,” *IEEE Trans. Inform. Theory*, February 2013.
[3] E. Stathakis, M. Skoglund and L. Rasmussen, “On beamforming and orthogonal space-time block coding in cognitive radio networks with imperfect CSI and interference,” *IEEE Trans. Commun.*, March 2013.
[4] M. Khormuji, A. El Gamal and M. Skoglund, “The state-dependent relay channel: Achievable rates and capacity of a semi-deterministic class,” *IEEE Trans. Inform. Theory*, May 2013.
[5] Z. Si, R. Thobaben and M. Skoglund, “Bilayer LDPC convolutional codes for decode-and-forward relaying,” *IEEE Trans. Commun.*, August 2013.
[6] M. Andersson, R. Schaefer, T. Oechtering and M. Skoglund, “Polar coding for

bidirectional broadcast channels with common and confidential messages," *IEEE J-SAC*, September 2013.
[7] D. Sundman, S. Chatterjee and M. Skoglund, "Compressed sensing over networks," *MDPI Journal of Sensor and Actuator Networks*, (invited paper), vol. 3, no. 1, pp. 1-25, January 2014.
[8] A. Zaidi, T. Oechtering, S. Yüksel and M. Skoglund, "Stabilization of linear systems over Gaussian networks," *IEEE Trans. Automatic Control*, September 2014.
[9] S. Huang and M. Skoglund, "Induced transformations of recurrent a.m.s. dynamical systems," *Stochastics and dynamics*, June 2014.
[10] P. Larsson, Lars K. Rasmussen and M. Skoglund, "Throughput analysis of ARQ schemes in Gaussian block fading channels," *IEEE Trans. Commun.*, July 2014.
[11] D. Sundman, S. Chatterjee and M. Skoglund, "Distributed greedy pursuit algorithms," *Signal Proc.*, December 2014.
[12] H. Do, T. Oechtering and M. Skoglund, "Layered coding for the interference channel with a relay," *IEEE Trans. Inform. Theory*, October 2014.
[13] H. Ghauch, T. Kim, M. Bengtsson and M. Skoglund, "Distributed low-overhead schemes for multi-stream MIMO interference channels," *IEEE Trans. Signal Proc.* Accepted for publication.
[14] K. Kittichokechai, T. Oechtering and M. Skoglund, "Coding with action-dependent side information and additional reconstruction requirements," *IEEE Trans. Inform. Theory.* Accepted for publication.

Journal Papers (in review/revision)

[15] S. Huang and M. Skoglund, "On linear coding over finite rings and applications to computing," *IEEE Trans. Inform. Theory.* Revised September 2013.
[16] C. Wang and M. Skoglund, "Multi-user multi-hop relay networks: Transmission schemes and degrees of freedom," *IEEE Trans. Wireless Commu*n. Revised February 2015.
[17] K. Kittichokechai, Y.-K. Chia, T. Oechtering, M. Skoglund and T. Weissman, "Secure source coding with a public helper," *IEEE Trans. on Inform. Theory.* Submitted July 2013.
[18] H. Do, T. Oechtering, M. Skoglund and M. Vu, "Interfering relay channels," *IEEE Trans. Inform. Theory.* Submitted July 2013.
[19] E. Stathakis, L. K. Rasmussen and M. Skoglund, "Closed-form capacity result for interference limited environments with mixed fading," IEEE Trans. Commun. Submitted July 2014.
[20] K. Kittichokechai, Y.-K. Chia, T. Oechtering and M. Skoglund, "Secure source coding with action dependent side information," *IEEE Trans. Inform. Theory.* Submitted October 2014.

Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Mikael Skoglund	20

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	2018	2019	Total
1	Other personnel without doctoral degree	Doktorand 1	50	245,000	260,000	295,000	328,000	1,128,000
2	Other personnel without doctoral degree	Doktorand 2	50	245,000	260,000	295,000	328,000	1,128,000
3	Other personnel with doctoral degree	PostDoc	66	470,000	480,000	490,000	500,000	1,940,000
	Total			960,000	1,000,000	1,080,000	1,156,000	4,196,000

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

	Type of premises	2016	2017	2018	2019	Total
1	Kontor	80,000	90,000	100,000	100,000	370,000
	Total	80,000	90,000	100,000	100,000	370,000

Running Costs

Running Cost	Description	2016	2017	2018	2019

Depreciation costs

Depreciation cost	Description	2016	2017	2018	2019

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	2018	2019	Total, applied	Other costs	Total cost
Salaries including social fees	960,000	1,000,000	1,080,000	1,156,000	4,196,000	2,400,000	6,596,000
Running costs					0		0
Depreciation costs					0		0
Premises	80,000	90,000	100,000	100,000	370,000		370,000
Subtotal	1,040,000	1,090,000	1,180,000	1,256,000	4,566,000	2,400,000	6,966,000
Indirect costs	312,000	349,000	379,000	408,000	1,448,000	827,000	2,275,000
Total project cost	1,352,000	1,439,000	1,559,000	1,664,000	6,014,000	3,227,000	9,241,000

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

As described in the project plan, we plan to engage two PhD students and one postdoc. We ask VR to fund 50% of the PhD students and 66% of the postdoc. Both PhD students and the postdoc will however be active at 80% in the project. Their remaining time will be spent on teaching and department duties. The remaining part of the time spent in the project will be funded by KTH faculty funding for research and research education; the corresponding cost estimated has been stated under 'annan kostnad'. The time they will allocate to teaching will be funded by KTH funding for undergraduate teaching.

To get the figures for indirect cost, the following templates were used (as specified by the head of economics for the KTH School of EE, for the year 2015; used as estimates for the years 2016-19):

KTH central administration OH: 23.6%
KTH School of EE OH: 6.3%
KTH School of EE, Dept. of Communication Theory OH: 6.7%

The OH templates are applied to the direct cost for salaries.

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017	2018	2019

CV and publications

CV

Curriculum Vitae Mikael Skoglund, March 2015

Degrees and Appointments

October 2003	Professor (Communication Theory)	Royal Institute of Technology (KTH)
February 2001	Docent (Signal Processing)	KTH
April 1997	Ph.D. in E.E. (Information Theory)	Chalmers University of Technology (CTH)
August 1992	M.Sc. in E.E.	CTH

Ph.D. adviser: Per Hedelin; Thesis title: On Soft Decoding and Robust VQ

Academic Positions and Appointments

Jun 2012 – present	Academic coordinator, KTH–Ericsson strategic partnership
Jan 2009 – present	Vice-Dean, KTH School of Electrical Engineering
Jul 2006 – present	Program Director, KTH Linnaeus ACCESS Graduate School
Jan 2004 – present	Head (avdelningschef) of the Communication Theory Lab at KTH
Oct 2003 – present	Chaired Professor (professor, ämnesföreträdare), KTH
Jul 2010 – Jul 2011	Stockholm Node Coordinator for Education, EIT ICT-Labs
Jan 2009 – Dec 2009	Program Director, National Graduate School of Telecommunication (GST)
Jul 2002 – Dec 2005	Program Director, KTH Master Program in Wireless Systems
Oct 2001 – Sep 2003	Associate Professor (universitetslektor), KTH
Mar 1998 – Sep 2001	Assistant Professor (forskarassistent), KTH
Aug 1997 – Feb 1998	Post Doc, KTH
Aug 1992 – Jul 1997	Teaching and research assistant (doktorand), CTH

Publications (full list available: `people.kth.se/~skoglund/`, link 'Publications')

Number of journal papers, published/accepted:	108
Number of journal papers, submitted/in revision:	24
Number of book chapters:	7
Number of conference papers:	293
Number of patents (or patent applications):	6

Most journal papers are full papers and have been published in IEEE periodicals.

All conference papers are peer-reviewed; most of them appear in IEEE conference proceedings. Most conference papers are full papers (4–7 pages).

h-index = 28; i10-index = 100; total no. of citations > 4200 (Google)

Honors and Awards

2014	"Best Student Paper Award" (for a paper at *IEEE ICASSP 2014*, co-author)
2013	IEEE Sweden VT/COM/IT "Best Journal Paper Award" (for a paper in *IEEE Trans-IT 2012*, co-author)
2012	Advisor for PhD student (Jinfeng Du) who recived the "Chinese Governmental Award for Outstanding Self-financed Students Abroad"
2012	"Best Paper Award" (for a paper at *IEEE Swe-CTW 2012*, co-author)
2011	"Best Paper Award" (for a paper at *IEEE WCNC 2011*, co-author)
2010	"Best Paper Award" (for a paper at *IEEE WCSP 2010*, co-author)
2003	"ADC Forum Best Paper Award," Honorable Mention (for a paper at *IEEE IMTC 2003*, co-author)
2002	"Excellent Paper Award" (for a paper at *IEEE WPMC 2002*, co-author)
1996	"Young Researcher Award" (for a paper at *IEEE/SITA ISITA 1996*, sole author)

PhD Students

Present students:

Hadi Ghauch (started 2011)
Efthymios Stathakis (started 2011)
Do Tan Tai (started 2010)
Zhao Wang (started 2010)
Farshad Naghibi (started 2010)
Peter Larsson (co-advisor)
Leefke Grosjean (co-advisor)
Sebastian Schiessl (co-advisor)
Minh Than Vu (co-advisor)

Previous students:

Sheng Huang (Ph.D. 2015)
Hamed Farhadi (Ph.D. 2014)
Frederic Gabry (Ph.D. 2014)
Kittipong Kittichokechai (Ph.D. 2014)
Dennis Sundman (Ph.D. 2014)
Amirpasha Shirazinia (Ph.D. 2014)
Mattias Andersson (Ph.D. 2014)
Ali Abbas Zaidi (Ph.D. 2013)
Ricardo Blasco Serrano (Ph.D. 2013)
Hieu Trong Do (Ph.D. 2013)
Nicolas Schrammar (Ph.D. 2013)
Zhongwei Si (Ph.D. 2013)
JinFeng Du (Ph.D. 2012)
Johannes Kron (Karlsson) (Ph.D. 2011)
Sha Yao (Ph.D. 2011)
Majid Khormuji (Ph.D. 2011)
Lei Bao (Ph.D. 2009)
Thanh Tung Kim (Ph.D. 2008)
Niklas Wernersson (Ph.D. 2008)
Joakim Jalden (Ph.D. 2006, co-advisor)
Tomas Sköllermo–Andersson (Lic. Eng. 2005)
Jochen Giese (Ph.D. 2005)
Tomas Andersson (Ph.D. 2005, co-advisor)
Henrik Lundin (Ph.D. 2005, co-advisor)
George Jöngren (Ph.D. 2003, co-advisor)

Post Docs

Moritz Wiese	2014–
Jinfeng Du	2013–
Somayeh Salimi	2011–14
Mikko Vehkaperä	2010–13
Majid Khormuji	2011–13
Taejoon Kim	2012
Chao Wang	2009–12
Saikat Chatterjee	2009–12
Vishwambhar Rathi	2009–10
Lei Bao	2009–10
Tobias Oechtering	2008–10
Ming Xiao	2007–08
Ragnar Thobaben	2007–08

Selected Services and Activities

Member of Regular Editorial Boards: IEEE Transactions on Information Theory (2009–2012), IEEE Transactions on Communications (2003–2009); PeerJ Compuer Science (2015–)

Member of Editorial Boards for Special Issues: MDPI/Information "Communication theory" (2015); Hindawi, "Advanced coexistence technologies" (2011–12); MDPI/Entropy "Information theory applied to communications and networking" (2011–12)

TPC chair at IEEE Swe-CTW 2011; TPC track chair at IEEE ICCCN 2011 and SPAWC 2013; Special session organizer at IEEE SPAWC 2013 and IEEE ISWCS 2011; TPC member for international (mostly IEEE) conferences, multiple occasions (including ISIT, ITW, APCC, Globecom, VTC, QBSC, PIMRC, NecSys, WCSP, ChinaCOM, CROWNCOM, EUSIPCO, ISITA, ISWCS, WCNC); Member of the organization committees at IEEE Swe-CTW 2011, the Turbo Symposium 2012, IEEE SPAWC 2015; Session chair (numerous occasions).

Reviewer of journal and conference papers (numerous) and textbooks (several). External reviewer for funding proposals (multiple occasions), serving e.g. The European Research Council; The Swedish Research Council; The Academy of Finland; The Danish Council for Independent Research; WWTF [Austria]; Istituto Superiore Mario Boella [Italy]; The Natural Sciences and Engineering Research Council of Canada; The Irish Science Foundation; The National Research Promotion Foundation, Cyprus.

Faculty Opponent for five PhD dissertations (Supélec, Paris, twice; NTNU, Trondheim; Aalborg; Porto); and five Licentiate degree presentations. Member of PhD graduation committees (betygsnämnder) on numerous (>20) occasions.

External Area Expert for faculty positions, docent-appointments and promotions (multiple occasions e.g. at Georgia Tech, NYU, Tel Aviv Univ., Univ. Cyprus, Eurecom, Uppsala Univ., Lund Univ., Linköping Univ., NTNU Trondheim, Oslo Univ.)

International Collaboration in the form of joint papers published with distinguished members of the faculty at Harvard, MIT, New Mexico State, Oregon State, Princeton, Purdue, Stanford, Tufts (USA); Univ. Toronto, Queens Univ. (Canada); Sharif, City Univ. Hong Kong, IISc, Taiwan Nat. Chiao-Tung Univ., Tokyo Inst Tech, Tsinghua, Technion (Middle-east, Asia); Aalto Univ., Univ. Helsinki, TU Dresden, TU Munich, NTNU Trondheim (Europe)

Invited Contributions and Talks at conferences, workshops and visits, numerous occasions, including: CTH, 2015; GlobalSIP, 2014; ITA, San Diego, 2013, 2014; GlobalSIP, 2013; BlackSeaCOM, 2013; SPAWC, 2013; Comms. and control, Lund, 2012; Inf. theory and coding for coop. networks, Paris, 2012; ISCCSP 2012; SNOW, Norway, 2012; CISS, Princeton, 2012; European Wireless 2011 & 2012; Supélec, Paris, 2011; Telecom Paris Tech., 2011; EUSIPCO 2011; ISWCS 2009; CONET 2008; IEEE ACC 2007; USC, Los Angeles, 2007

Publication list

Publications of Mikael Skoglund, March 2015

Bibliometric data for the five most cited papers, listed below, have been gathered from Google Scholar. Skoglund's total number of Google citations exceeds 4200.

The five publications judged most relevant for this project are marked by a $\star$. Also, the number of (Google) citations has been stated for journal papers with 20 or more citations and for conference papers with 10 or more citations, self citations excluded (definition of 'self citation' = citation from paper with Skoglund as author).

For a complete list of publications please refer to: `people.kth.se/~skoglund/`
This webpage also publishes a pointer to Skoglund's Google Scholar profile where citation data for all publications can be easily accessed.

Five Most Cited Publications (all years)

- G. Jöngren, M. Skoglund and B. Ottersten, "Combining beamforming and orthogonal space–time block coding," *IEEE Transactions on Information Theory*, vol. 48, no. 3, pp. 611-627, March 2002.
  Number of citations: 526
- T. T. Kim and M. Skoglund, "On the expected rate of slowly fading channels with quantized side information," *IEEE Transactions on Communications*, vol. 55, no. 4, pp. 820-829, April 2007.
  Number of citations: 113
- M. Xiao and M. Skoglund "Multiple-user cooperative communications based on linear network coding," *IEEE Transactions on Communications*, vol. 58, no. 12, pp. 3345-3351, November 2010.
  Number of citations: 111
- M. Skoglund and G. Jöngren, "On the capacity of a multiple-antenna communication link with channel side information," *IEEE Journal on Selected Areas in Communications*, vol. 21, no. 3, pp. 395-405, April 2003.
  Number of citations: 97
- T. T. Kim and M. Skoglund, "Diversity–multiplexing tradeoff in MIMO channels with partial CSIT," *IEEE Transactions on Information Theory*. vol. 53, no. 8, pp. 2743-2759, August 2007.
  Number of citations: 90

Journal Papers (published/accepted, starting from 2007)

[1] J. Giese and M. Skoglund, "Single- and multiple-antenna constellations for communication over unknown frequency-selective fading channels" *IEEE Transactions on Information Theory*. vol. 53, no. 4, pp. 1584–1594, April 2007.

[2] T. T. Kim and M. Skoglund, "On the expected rate of slowly fading channels with quantized side information," *IEEE Transactions on Communications*. vol. 55, no. 4, pp. 820–829, April 2007. **113 citations**

[3] J. Giese and M. Skoglund, "Space–time constellation design for partial CSI at the receiver," *IEEE Transactions on Information Theory*. vol. 55, no. 8, pp. 2715–2731, August 2007. **20 citations**

[4] T. T. Kim and M. Skoglund, "Diversity multiplexing tradeoff in MIMO channels with partial CSIT," *IEEE Transactions on Information Theory*, vol. 55, no. 8, pp. 2743–2759, August 2007. **90 citations**

[5] T. Andersson and M. Skoglund, "A COVQ-based image coder for channels with bit-errors and erasures," *IEEE Transactions on Communications*, vol. 56, no. 2, pp. 161–165, February 2008.

[6] T. T. Kim, M. Bengtsson, E. G. Larsson and M. Skoglund, "Combining long-term and low rate short-term channel state information over correlated MIMO channels," *IEEE Transactions on Wireless Communications*, vol. 7, no. 7, pp. 2409–2414, July 2008.

[7] S. Yao, M. Khormuji and M. Skoglund, "Sawtooth relaying," *IEEE Communication Letters*, vol. 12, no. 9, pp. 612–614, September 2008. **20 citations**

[8] T. T. Kim, G. Caire and M. Skoglund, "Decode-and-forward relay channels with quantized channel state feedback: An outage exponent analysis," *IEEE Transactions on Information Theory*, vol. 54, no. 10, pp. 4548–4564, October 2008. **45 citations**

[9] T. T. Kim, M. Skoglund and G. Caire, "On cooperative source transmission with partial rate and power control," *IEEE Journal of Selected Areas in Communications*, vol. 26, no. 8, pp. 1408–1418, October 2008.

[10] C. Ramesh, A. Rusu, M. Ismail and M. Skoglund, "System co-optimizaiton in wireless receiver design with TrACS," *Analog Integrated Circuits and Signal Processing (Springer)*, vol. 57, pp. 117–127, November 2008.

[11] M. Skoglund and E. G. Larsson, "Optimal modulation for known interference," *IEEE Transactions on Communications*, vol. 56, no. 11, pp. 1892–1899, November 2008.

[12] E. G. Larsson M. Skoglund, "Cognitive radio in a frequency planned environment: Some basic limits," *IEEE Transactions on Wireless Communications*, vol. 7, no. 12, pp. 4800–4806, December 2008. **64 citations**

[13] T. T. Kim, M. Skoglund and G. Caire, "On source transmission over MIMO channels with limited feedback," *IEEE Transactions on Signal Processing*, vol. 57, no. 1, pp. 324–341, January 2009.

[14] S. Yao and M. Skoglund, "Hybrid digital–analog relaying for cooperative transmission over slow fading channels," *IEEE Transactions on Information Theory*, vol. 55, no. 3, pp. 944–951, March 2009.

[15] T. T. Kim, M. Skoglund and G. Caire, "Quantifying the loss of compress-forward relaying without Wyner–Ziv coding," *IEEE Transactions on Information Theory*, vol. 55, no. 4, pp. 1529–1533, April 2009. 25 citations

[16] N. Wernersson, J. Karlsson and M. Skoglund, "Distributed quantizers over noisy channels," *IEEE Transactions on Communications*, vol. 57, no. 6, pp. 1693-1700, June 2009. **29 citations**

[17] N. Wernersson, M. Skoglund and T. Ramstad, "Polynomial based analog source-channel codes," *IEEE Transactions on Communications*, vol. 57, no. 9, pp. 2600-2606, September 2009. **20 citations**

[18] N. Wernersson and M. Skoglund, "Nonlinear coding and estimation for correlated data in wireless sensor networks," *IEEE Transactions on Communications* vol. 57, no. 10, October 2009. **20 citations**

[19] H. Lundin, P. Händel and M. Skoglund, "Bounds on the performance of analog-to-digital converter look-up table post-correction," *Journal of the International Measurement Confederation (Elsevier)* vol. 42, no. 8, pp. 1164-1175, October 2009.

[20] J. Karlsson and M. Skoglund, "Optimized low-delay source-channel-relay mappings," *IEEE Transactions on Communications*, vol. 58, no. 5, pp. 1397-1404, May 2010. 20 citations

[21] T. T. Kim and M. Skoglund, "On the DMT-optimality of non-dynamic DF relaying in asymmetric Nakagami fading Channels," *IEEE Transactions on Information Theory*, vol. 56, no. 7, pp. 3304-3309, July 2010.

[22] M. Khormuji and M. Skoglund, "On instantaneous relaying," *IEEE Transactions on Information Theory*, vol. 56, no. 7, pp. 3378-3394, July 2010. 28 citations

[23] M. Khormuji, A. Zaidi and M. Skoglund, "Interference management using nonlinear relaying," *IEEE Transactions on Communications*, vol. 58, no. 7, pp. 1924-1930, July 2010.

[24] S. Yao and M. Skoglund, "Analog network coding mappings in Gaussian mutiple-access relay channels," *IEEE Transactions on Communications*, vol. 58, no. 7, pp. 1973-1983, July 2010.

[25] M. Andersson, V. Rathi, R. Thobaben, J. Kliewer and M. Skoglund, "Nested polar codes for wiretap and relay channels," *IEEE Communication Letters*, vol. 14, no. 8, pp. 752-754, August 2010. **62 citations**

[26] J. Karlsson and M. Skoglund, "Design and performance of optimized relay mappings," *IEEE Transactions on Communications*, vol. 58, no. 9, pp. 2718-2724, September 2010.

[27] M. Xiao and M. Skoglund, "Multiple-user cooperative communications based on linear network coding," *IEEE Transactions on Communications*, vol. 58, no. 11, November 2010. **111 citations**

[28] C. Wang, Y. Fan, J. S. Thompson, M. Skoglund, and H. V. Poor, "Approaching the optimal diversity-multiplexing tradeoff in a four-node uplink cooperative cellular network," *IEEE Transactions on Wireless Communications*, vol. 9, no. 12, pp. 3690 - 3700, December 2010.

[29] V. Rathi, E. Aurell, L. Rasmussen and M. Skoglund, "Bounds on threshold of regular random k-SAT," *Lecture Notes in Computer Science*, vol. 6175, pp. 264-277, 2010

[30] L. Bao, M. Skoglund and K. H. Johansson, "Iterative encoder–controller design for feedback control over noisy channels," *IEEE Transactions on Automatic Control*, vol. 56, no. 2, pp. 265-278, February 2011. **21 citations**

[31] C. Wang, M. Xiao and M. Skoglund, "Diversity-multiplexing tradeoff analysis of coded multi-user relay networks," *IEEE Transactions on Communications*, vol. 59, no. 7, pp. 1995-2005, July 2011.

[32] J. Du, E. G. Larsson, M. Xiao and M. Skoglund, "Optimal symbol-by-symbol Costa precoding for a relay-aided downlink channel," *IEEE Transactions on Communications*, vol. 59, no. 8, pp. 2274-2284, August 2011.

[33] J. Kron, D. Persson, M. Skoglund and E. G. Larsson, "Closed-form sum-MSE minimization for the two-user Gaussian MIMO broadcast channel," *IEEE Communication Letters*, vol. 15, no. 9, pp. 950-592, September 2011.

[34] J. Du, M. Xiao and M. Skoglund, "Cooperative network coding strategies for wireless relay networks with backhaul," *IEEE Transactions on Communications*, vol. 59, no. 9, pp. 2502-2514, September 2011. **20 citations**

[35] S. Shi, E. G. Larsson and M. Skoglund, "Codebook design and hybrid digital/analog coding for parallel Rayleigh fading channels," *IEEE Transactions on Signal Processing*, vol. 59, no. 10, pp. 5091-5096, October 2011.

[36] S. Chatterjee, D. Sundman, M. Vekhaperä and M. Skoglund, "Projection and look ahead based strategies for atom selection," *IEEE Transactions on Signal Processing*, vol. 60, no. 2, pp. 634-647, February 2012. **21 citations**

[37] D. Persson, J. Kron, M. Skoglund and E. G. Larsson, "Joint source-channel coding for the MIMO Broadcast Channel," *IEEE Transactions on Signal Processing*, vol. 60, no. 4, pp. 2085-2090, April 2012.

[38] Z. Si, R. Thobaben and M. Skoglund, "Rate-compatible LDPC convolutional codes achieving the capacity of the BEC," *IEEE Transactions on Information Theory*, vol. 58, no. 6, pp. 4021-4029, June 2012. **Paper award.**

[39] L. Bao, C. Fishione, M. Skoglund and K. H. Johansson, "Rate allocation with power constraints for quantized control over binary symmetric channels," *IEEE Transactions on Signal Processing*, vol. 60, no. 6, pp. 3188–3202, June 2012.

[40] N. Schrammar and M. Skoglund, "Transmission strategies for wireless relay networks obtained from linear finite-field deterministic models," *IEEE Transactions on Communications*, vol 60, no. 8, pp. 2167–2176, August 2012. ⋆

[41] C. Wang, H. Farhadi and M. Skoglund, "Achieving the degrees of freedom of wireless multi-user relay networks," *IEEE Transactions on Communications*, vol. 60, no. 9, pp. 2612–2622, September 2012.

[42] P. A. Floor, A. N. Kim, N. Wernersson, T. A. Ramstad, M. Skoglund and I. Balasingham, "Zero-delay joint source–channel coding for a bivariate Gaussian on a Gaussian MAC," *IEEE Transactions on Communications* vol. 60, no. 10, pp. 3091–3102, October 2012.

[43] M. Khormuji and M. Skoglund, "Capacity of two semideterministic classes of multiple-access relay channels," *IEEE Communication Letters*, vol. 16, no. 10, pp. 1529–1531, October 2012.

[44] R. Blasco Serrano, V. Rathi, M. Andersson, R. Thobaben and M. Skoglund, "Polar codes for cooperative relaying," *IEEE Transactions on Communications*, vol. 60, no. 11, pp. 3263-3273, November 2012.

[45] D. Persson, E. G. Larsson and M. Skoglund, "Joint source–channel decoding over MIMO channels based on partial marginalization," *IEEE Transactions on Signal Processing*, vol. 60, no. 12, pp. 6734–6739, December 2012.

[46] M. Khormuji and M. Skoglund, "Capacity bounds and mapping design for binary symmetric relay channels," *MDPI Entropy*, vol. 14, no. 12, pp. 2589–2610, December 2012.

[47] M. Xiao, J. Kliewer and M. Skoglund, "Design of network codes for multiple-user multiple-relay wireless networks," *IEEE Transactions on Communications*, vol. 60, no. 12, pp. 3755-3766, December 2012. **72 citations**

[48] T. Oechtering and M. Skoglund, "Bidirectional broadcast channel with random states non-causally known at the encoder," *IEEE Transactions on Information Theory*, vol. 59, no. 1, pp. 64-75, January 2013.

[49] V. Rathi, M. Andersson, R. Thobaben, J. Kliewer and M. Skoglund, "Performance analysis and design of two edge type LDPC codes for the BEC wiretap channel," *IEEE Transactions on Information Theory*, vol. 59, no. 2, pp. 1048-1064, February 2013.

[50] S. Yao, T. Kim, M. Skoglund and H. V. Poor, "Half-duplex relaying over slow fading channels based on quantize-and-forward," *IEEE Transactions on Information Theory*, vol. 59, no. 2, pp. 860-872, February 2013.

[51] H. Do, T. Oechtering and M. Skoglund, "On asymmetric interference networks with cooperating receivers," *IEEE Transactions on Communications*, vol. 61, no. 2, pp. 554-563, February 2013.

[52] E. Stathakis, M. Skoglund and L. Rasmussen, "On beamforming and orthogonal space-time block coding in cognitive radio networks with imperfect CSI and interference," *IEEE Transactions on Communications*, vol. 61, no. 3, pp. 961-972, March 2013.

[53] Z. Wang, M. Xiao, C. Wang and M. Skoglund,"Degrees of freedom of multi-hop MIMO broadcast networks with delayed CSIT," *IEEE Wireless Communication Letters*, vol. 2, no. 2, pp. 207-210, April 2013.

[54] M. Khormuji, A. El Gamal and M. Skoglund, "The state-dependent relay channel: Achievable rates and capacity of a semi-deterministic class," *IEEE Transactions on Information Theory,* vol. 59, no. 5, pp. 2629-2638, May 2013.

[55] R. Blasco Serrano, J. Lv, R. Thobaben, E. Jorswieck and M. Skoglund, "Multi-antenna transmission for underlay and overlay cognitive radio with explicit message learning phase," *EURASIP Journal on Wireless Communications and Networking*, 2013:195, doi:10.1186/1687-1499-2013-195, July 2013

[56] J. Du, M. Xiao, M. Skoglund and M. Medard, "Wireless multicast relay networks with limited-rate source-conferencing," *IEEE Journal of Selected Areas in Communications*, vol. 31, no. 8, pp. 1390-1401, August 2013.

[57] Z. Si, R. Thobaben and M. Skoglund, "Bilayer LDPC convolutional codes for decode-and-forward relaying," *IEEE Transactions on Communications*, vol. 61, no. 8, pp. 3086-3099, August 2013.

[58] A. Zaidi, S. Yüksel, T. Oechtering and M. Skoglund, "On optimal policies for control and estimation over Gaussian relay channels," *Automatica*, vol. 49, no. 9, pp. 2892-2897, September 2013.

[59] S. Salimi, M. Skoglund, J. Golic, M. Salmasizadeh, and M. Reza Aref, "Key agreement over generalized multiple access channels using noiseless and noisy feedback," *IEEE J-SAC*, vol. 31, no. 9, pp. 1765-1778, September 2013.

[60] M. Andersson, R. Schaefer, T. Oechtering and M. Skoglund, "Polar coding for bidirectional broadcast channels with common and confidential messages," *IEEE J-SAC*, vol. 31, no. 9, pp. 1901-1908, September 2013.

[61] T. T. Do, T. Oechtering and M. Skoglund, "Optimal transmission for the MIMO bidirectional broadcast channel in the wideband regime," *IEEE Transactions on Signal Processing*, vol. 61, no. 20, pp. 5103-5116, October 2013.

[62] A. Shirazinia, S. Chatterjee and M. Skoglund, "Analysis-by-synthesis quantization for compressed sensing measurements," *IEEE Transactions on Signal Processing*, vol. 61, no. 22, pp. 5789-5800, November 2013.

[63] D. Sundman, S. Chatterjee and M. Skoglund, "Compressed sensing over networks," *MDPI Journal of Sensor and Actuator Networks, (invited paper)*, vol. 3, no. 1, pp. 1-25, January 2014.

[64] E. Stathakis, J. Jalden, L. Rasmussen and M. Skoglund, "Uniformly improving maximum-likelihood SNR estimation of known signals in Gaussian channels," *IEEE Transactions on Signal Processing*, vol. 62, no. 1, pp. 156-167, January 2014.

[65] J. Kron, F. Alajaji and M. Skoglund, "Low-delay joint source-channel mappings for the Gaussian MAC," *IEEE Communication Letters*, vol. 18, no. 2, pp. 249–252, February 2014.

[66] F. Gabry, N. Li, N. Schrammar, M. Girnyk, L. Rasmussen and M. Skoglund, "On the optimization of the secondary transmitter's strategy in cognitive radio channels with secrecy," *IEEE Journal of Selected Areas in Communication*, vol. 32, no. 3, pp. 451–463, March 2014.

[67] A. Zaidi, T. Oechtering, S. Yüksel and M. Skoglund "Stabilization of linear systems over Gaussian networks," *IEEE Transactions on Automatic Control*, vol. 59, no. 9, pp. 2369-2384, September 2014. ⋆

[68] M. J. Emadi, M. N. Khormuji, M. Skoglund and M. R. Aref, "Multi-layer Gelfand-Pinsker strategies for the generalized multiple-access channel," *IET Communications*, vol. 8, no. 8, pp. 1296-1308, 2014.

[69] R. Blasco Serrano, D. Zachariah, D. Sundman, M. Skoglund and R. Thobaben, "A measurement rate-MSE tradeoff for compressive sensing through partial support recovery," *IEEE Transactions on Signal Processing*, vol. 62, no. 18, pp. 4643-4658, September 2014. ⋆

[70] S. Chatterjee et al., "SEK: Sparsity exploiting k-mer-based estimation of bacterial community composition," *Bioinformatics*, vol. 30, no. 17, pp. 2423-2431, September 2014.

[71] S. Huang and M. Skoglund, "Induced transformations of recurrent a.m.s. dynamical systems," *Stochastics and dynamics*, vol. 15, no. 2, June 2014.

[72] N. Schrammar, M. Skoglund, C. Wang and L. Rasmussen, "New achievable rates for Gaussian partially cognitive interference channels with multiple cognitive pairs," *IEEE Transactions on Communications*, vol. 62, no.6, pp. 2051-2060, June 2014.

[73] P. Larsson, Lars K. Rasmussen and M. Skoglund, "Throughput analysis of ARQ schemes in Gaussian block fading channels," *IEEE Transactions on Communications*, vol. 62, no. 7, pp. 2569-2588, July 2014.

[74] Z. Wang, M. Xiao and M. Skoglund, "Secrecy degrees of freedom of the 2-by-2-by-2 interference channel with delayed CSIT," *IEEE Wireless Communication Letters*, vol. 3, no. 4, pp.341-344, August 2014.

[75] D. Sundman, S. Chatterjee and M. Skoglund, "Distributed greedy pursuit algorithms," *Signal Processing*, vol. 105, pp. 298-315, December 2014.

[76] A. Shirazinia, S. Chatterjee and M. Skoglund, "Joint source-channel vector quantization for compressed sensing," *IEEE Transactions on Signal Processing*, vol. 62, no. 14, pp. 3667-3681, July 2014.

[77] M. Malek-Mohammadi, M. Babaie-Zadeh and M. Skoglund, "Iterative concave rank approximation for recovering low-rank matrices," *IEEE Transactions on Signal Processing*, vol. 62, no. 20, pp. 5213-5226, October 2014.

[78] H. Do, T. Oechtering and M. Skoglund, "Layered coding for the interference channel with a relay," *IEEE Transactions on Information Theory*, vol. 60, no. 10, pp. 6154-6180, October 2014.

[79] L. Grosjean, L. K. Rasmussen, R. Thobaben and M. Skoglund, "Systematic LDPC convolutional codes: Asymptotic and finite-length anytime properties," *IEEE Transactions on Communications*, vol. 62, no. 12, pp. 4165-4183, December 2014.

[80] T. Kim, Z.-Y. Jin, D. J. Love and M. Skoglund "An approach to sensor network throughput enhancement by PHY-aided MAC," *IEEE Transactions on Wireless Communications*, vol. 14, no. 2., pp. 670-684, February 2015.

[81] A. Koochakzadeh, M. Malek-Mohammadi, M. Babaie-Zadeh and M. Skoglund, "Multi-antenna assisted spectrum sensing in spatially correlated noise environments," *Signal Processing*, vol. 108, pp. 69-76, March 2015.

[82] H. Farhadi, C. Wang and M. Skoglund, "Distributed transceiver design and power control for wireless MIMO interference networks," *IEEE Transactions on Wireless Communications*, vol. 14, no. 3., pp. 1199-1212, March 2015.

[83] Z. Wang, M. Xiao, C. Wang and M. Skoglund, "Degrees of freedom of two-hop MISO broadcast networks with mixed CSIT," *IEEE Transactions on Wireless Communications*. Accepted for publication.

[84] A. Shirazinia, A. Zaidi, L. Bao and M. Skoglund,"Dynamic source-channel coding for estimation and control over binary symmetric channels," *IET Control Theory and Applications*. Accepted for publication.

[85] M. Gerami, M. Xiao and M. Skoglund, "Partial repair for wireless caching networks with broadcast channels," *IEEE Wireless Communications Letters*. Accepted for publication.

[86] K. Kittichokechai, T. Oechtering and M. Skoglund, "Coding with action-dependent side information and additional reconstruction requirements," *IEEE Transactions on Information Theory*. Accepted for publication.

[87] H. Ghauch, T. Kim, M. Bengtsson and M. Skoglund, "Distributed low-overhead schemes for multi-stream MIMO interference channels," *IEEE Transactions on Signal Processing*. Accepted for publication.

[88] F. Naghibi, S. Salimi and M. Skoglund, "The CEO problem with secrecy constraints," *IEEE Transactions on Information Forensics and Security*. Accepted for publication.

[89] M. Malek-Mohammadi, M. Babaie-Zadeh and M. Skoglund,"Performance guarantees for the Schatten-p quasi-norm minimization in recovery of low-rank matrices," *Signal Processing*. Accepted for publication.

[90] P. A. Floor, A. N. Kim, T. A. Ramstad, I. Balasingham, N. Wernersson and M. Skoglund," On Joint source-channel coding for a multivariate Gaussian on a Gaussian MAC," *IEEE Transactions on Communications*. Accepted for publication.

Conference Papers (published/accepted, starting from 2007)

[91] J. Karlsson, N. Wernersson and M. Skoglund, "Distributed scalar quantizers for noisy channels," In *Proc. IEEE ICASSP, 2007*.

[92] M. Skoglund and E. G. Larsson "Optimal modulation for known interference," In *Proc. IEEE ICASSP, 2007*.

[93] T. Kim, M. Bengtsson and M. Skoglund, "Quantized feedback design for MIMO broadcast channels," In *Proc. IEEE ICASSP, 2007*.

[94] N. Wernersson, J. Karlsson and M. Skoglund, "Distributed scalar quantizers for Gaussian channels," in *Proc. IEEE ISIT*, 2007.

[95] L. Bao, M. Skoglund and K.-H. Johansson, "On optimal system design for feedback control over noisy channels," in *Proc. IEEE ISIT*, 2007.

[96] T. T. Kim, M. Skoglund and G. Caire, "Distortion exponents over fading MIMO channels with quantized feedback," in *Proc. IEEE ISIT*, 2007.

[97] L. Bao, M. Skoglund and K. H. Johansson, "A scheme for joint quantization, error protection and feedback control over noisy channels," in *Proc. IEEE ACC* (invited paper), July 2007. **10 citations**

[98] T. T. Kim, G. Caire and M. Skoglund, "On the outage exponent of fading relay channels with partial channel state information," in *Proc. IEEE ITW*, 2007.

[99] E. G. Larsson and M. Skoglund, "Cognitive radio in a frequency planned environment: Can it work?," in *Proc. IEEE Globecom*, 2007. **10 citations**

[100] N. Wernersson, M. Skoglund and T. Ramstad, "Analog source-channel codes based on orthogonal polynomials," in *Proc. 41st Asilomar Conference on Signals, Systems and Computers*, 2007.

[101] S. Yao and M. Skoglund "Dimension expansion relaying for slow fading channels based on hybrid digital-analog source-channel coding," in *Proc. 41st Asilomar Conference on Signals, Systems and Computers*, 2007.

[102] T. Andersson and M. Skoglund, "Multiple description image coding based on multi-stage vector quantization," in *Proc. 41st Asilomar Conference on Signals, Systems and Computers*, 2007.

[103] J. Karlsson and M. Skoglund, "Joint source–channel mappings for the relay channel," in *Proc. IEEE ICASSP*, 2008.

[104] L. Bao, M. Skoglund and K.-H. Johansson, "On the separation principle in optimal control over noisy channels," in *Proc. IFAC WC*, 2008.

[105] S. Yao and M. Skoglund, "Dimension compression relaying for slow fading channels based on hybrid digital-analog source-channel coding," in *Proc. IEEE ICC*, 2008.

[106] B. Mercier, et al, "Sensor networks for cognitive radio: Theory and system design," in *Proc. ICT Mobile Summit*, 2008. **31 citations**

[107] J. Karlsson and M. Skoglund, "Design and performance of optimized relay mappings," in *Proc. IEEE CONET* (invited paper), 2008.

[108] L. Bao, M. Skoglund and K.-H. Johansson, "On the separation principle in optimal control over noisy channels," in *Proc. IFAC WC*, 2008.

[109] H. Sandberg, M. Rabi, M. Skoglund and K.-H. Johansson, "Estimation over heterogeneous sensor networks," in *Proc. IEEE CDC*, 2008. **26 citations**

[110] M. Khormuji and M. Skoglund, "The relay channel with partial causal state information," in *Proc. ISITA*, 2008.

[111] M. Khormuji and M. Skoglund, "Two-hop transmission with second-hop channel state information," in *Proc. ISITA*, 2008.

[112] N. Wernersson and M. Skoglund, "Nonlinear distributed source-channel coding over orthogonal additive white Gaussian noise channels," in *Proc. IEEE ICASSP*, 2009.

[113] S. Yao and M. Skoglund, "Analog network coding mappings in Gaussian multiple-access two-hop channels," in *Proc. IEEE ITW 2009.*

[114] M. Khormuji and M. Skoglund, "Instantaneous forwarding strategies for relay channels with known interference," in *Proc. IEEE ITW 2009.*

[115] M. Xiao and M. Skoglund, "M-user cooperative wireless communications based on nonbinary network codes," in *Proc. IEEE ITW 2009.* **42 citations**

[116] A. Osseiran et al, "Advances in device-to-device communication and network coding for IMT-advanced," in *Proc. ICT Mobile Summit 2009.* **51 citations**

[117] T. Oechtering and M. Skoglund, "Coding for the bidirectional broadcast channel with random states known at the encoder," in *Proc. IEEE ISIT 2009.*

[118] S. Yao and M. Skoglund, "Analog network coding mappings in Gaussian multiple-access relay channels," in *Proc. IEEE ISIT 2009.*

[119] M. Xiao and M. Skoglund, "Design of network codes for multiple-user multiple-relay wireless networks," in *Proc. IEEE ISIT 2009.*

[120] M. Khormuji and M. Skoglund, "On cooperative downlink transmission with frequency reuse," in *Proc. IEEE ISIT 2009.* **10 citations**

[121] L. Bao, M. Skoglund, C. Fischione and K. H. Johansson, "Optimized rate allocation for state estimation over noisy channels," in *Proc. IEEE ISIT 2009.*

[122] A. Zaidi, M. Khormuji, S. Yao and M. Skoglund, "Rate-maximizing mappings for memoryless relaying," in *Proc. IEEE ISIT 2009.* **12 citations**

[123] C.-L. Wu, M. Skoglund, C. Po-Ning and Y. Han, "A systematic space-time code design and its maximum-likelihood decoding for combined channel estimation and error correction," in *Proc. IEEE ISIT 2009.*

[124] M. Khormuji and M. Skoglund, "Piecewise linear relaying: Low complexity rarametric relaying," in *Proc. IEEE SPAWC 2009.*

[125] Z. Si, R. Thobaben and M. Skoglund, "On distributed serially concatenated codes," in Proc. *IEEE SPAWC 2009.* **10 citations**

[126] S. Zaidi, M. Khormuji, S. Yao and M. Skoglund, ”Optimized mappings for dimension-expansion relaying,” in *Proc. IEEE SPAWC 2009*.

[127] L. Bao, M. Skoglund, C. Fischione and K. H. Johansson, “Rate allocation for quantized control over noisy channels,” in *Proc. IEEE WiOPT/ConCom 2009.*

[128] J. Karlsson and M. Skoglund, “Analog distributed source-channel coding using sinusoids,” in *Proc. IEEE ISWCS 2009* (invited paper).

[129] L. Bao, M. Skoglund, C. Fischione and K. H. Johansson, “Optimized rate allocation for state feedback control over noisy channels,” in *Proc. IEEE CDC 2009.*

[130] H. Do, T. Oechtering, M. Skoglund “An achievable rate region for the Gaussian Z-interference channel with conferencing,” in *Proc. Allerton Conference on Communication, Control, and Computing 2009.*

[131] T. Oechtering, M. Andersson and M. Skoglund, ”Arimoto-Blahut algorithm for the bidirectional broadcast channel with side information,” in *Proc. IEEE ITW Taormina 2009.*

[132] S. Zaidi, M. Khormuji, S. Yao and M. Skoglund, “Optimized analog network coding strategies for the white Gaussian multiple-access relay channel,” in *Proc. IEEE ITW Taormina 2009.* **11 citations**

[133] L. Wang, V. Fodor and M. Skoglund, “Using cooperative transmission in wireless multihop networks,” in *Proc. IEEE PIMRC 2009.*

[134] N. Schrammar and M. Skoglund, “Uncoded transmission in wireless relay networks using deterministic modeling,” in *Proc. Asilomar 2009.*

[135] S. Yao and M. Skoglund, “Compress-forward relaying with quantized channel state feedback,” in *Proc. Asilomar 2009.*

[136] V. Rathi, M. Andersson, R. Thobaben, J. Kliewer and M. Skoglund, “Two edge type LDPC codes for the wiretap channel,” in *Proc. Asilomar 2009.* **14 citations**

[137] M. Khormuji and M. Skoglund, “On the capacity of the binary symmetric relay channel with a finite memory relay,” in *Proc. IEEE ITW 2010.*

[138] T. Oechtering, H. Do and M. Skoglund “Capacity-achieving coding for cellular downlink with bidirectional communication,” in *Proc. SCC 2010.*

[139] C. Wang, Y. Fan, J. Thompson, M. Skoglund and V. Poor, “Superposition-repetition-coded successive decode-and-forward relaying with limited destination-relay feedback, “ in *Proc. IEEE WCNC 2010.*

[140] Z. Si, R. Thobaben and M. Skoglund, “A practical approach to adaptive coding for the three-node relay channel, “ in *Proc. IEEE WCNC 2010.*

[141] L. Lu, M. Xiao, L. Rasmussen, M. Skoglund, G. Wu and S. Li, “Efficient network coding for wireless broadcasting,” in *Proc. IEEE WCNC 2010.* **23 citations**

[142] C. Wang, Y. Fan, J. Thompson, M. Skoglund and V. Poor, “Shifted successive decode-and-forward relaying: Towards the optimal diversity-multiplexing tradeoff for a four-node cooperative network,” in *Proc. IEEE ICC 2010.*

[143] L. Lu, M. Xiao, L. Rasmussen, M. Skoglund, G. Wu and S. Li, “Efficient wireless broadcasting based on systematic binary deterministic rateless codes,” in *Proc. IEEE ICC 2010.*

[144] H. Do, T. Oechtering and M. Skoglund, “The Gaussian Z-interference channel with rate-constrained conferencing decoders,” in *Proc. IEEE ICC 2010.*

[145] T. Oechtering, H. Do, and M. Skoglund, “Achievable rates for embedded bidirectional relaying in a cellular downlink,” in *Proc. IEEE ICC 2010.*

[146] R. Blasco Serrano, R. Thobaben and M. Skoglund, “Compress-and-forward relaying based on symbol-wise joint source-channel coding,” in *Proc. IEEE ICC 2010.*

[147] A. A. Zaidi, T. Oechtering and M. Skoglund, “Rate sufficient conditions for closed-loop control over AWGN relay channels,” in *Proc. IEEE ICCA 2010.*

[148] T. Oechtering and M. Skoglund, “Upper bound to error probability for coding on bidirectional broadcast channels,” in *Proc. IEEE ICT 2010.*

[149] Z. Si, R. Thobaben and M. Skoglund, “Adaptive channel coding for the three-node relay channel with limited channel-state information,” in *Proc. ISCCSP 2010.*

[150] V. Rathi, E. Aurell, L. Rasmussen and M. Skoglund, “Bounds on the threshold of regular random k-SAT,” in *Proc. SAT 2010.*

[151] L. Bao, A. Shirazinia and M. Skoglund, "Iterative encoder-controller design based on approximate dynamic programming," in *Proc. IEEE SPAWC 2010.*

[152] K. Kittichokechai, T. Oechtering, M. Skoglund and R. Thobaben, "Source and channel coding with action-dependent partially known two-sided state information," in *Proc. IEEE ISIT 2010.* **13 citations**

[153] S. Chatterjee and M. Skoglund, "Structured Gaussian mixture model based product VQ," in *Proc. Eusipco 2010.*

[154] E. Stathakis, N. Schrammar, L. Rasmussen and M. Skoglund, "On performance trade-offs in cognitive networks," in *Proc. IEEE International Conference on Wireless Information Technology and Systems 2010.*

[155] Z. Si, R. Thobaben and M. Skoglund, "Instantaneous relaying with bit-interleaved coded modulation: Design and optimization," in *Proc. ISTC 2010.*

[156] V. Rathi, E. Aurell, L. Rasmussen and M. Skoglund, "Bounds on thresholds related to maximum satisfiability of regular random formulas," in *Proc. ISTC 2010.*

[157] H. Do, T. Oechtering and M. Skoglund, "Coding for the Z channel with a digital relay link," in *Proc. ITW 2010, Dublin.*

[158] J. Du, M. Xiao and M. Skoglund, "Cooperative strategies for relay-aided multi-cell wireless networks with backhaul," in *Proc. ITW 2010, Dublin.*

[159] K. Kittichokechai, T. Oechtering and M. Skoglund, "Source coding with common reconstruction and action-dependent side information," in *Proc. ITW 2010, Dublin.*

[160] L. Bao and M. Skoglund, "Encoder-controller design for control over the binary-input Gaussian channel," in *Proc. ISITA 2010.*

[161] C. Wang, M. Xiao and M. Skoglund, "Diversity-multiplexing tradeoff analysis of multi-source multi-relay coded networks," in *Proc. ISITA 2010.*

[162] C. Wang, H. Farhadi and M. Skoglund, "On the degrees of freedom of parallel relay networks," in *Proc. Globecom 2010.*

[163] N. Schrammar and M. Skoglund, "Transmission strategies for Gaussian relay networks obtained from deterministic models," in *Proc. Globecom 2010.*

[164] A. Zaidi, T. Oechtering and M. Skoglund, "Sufficient conditions for closed-loop control over multiple-access and broadcast channels," in *Proc. IEEE CDC 2010.* **15 citations**

[165] J. Du, M. Xiao and M. Skoglund, "Capacity bounds for relay-aided wireless multiple multicast with backhaul," in *Proc. WCSP 2010.* **Paper award.**

[166] V. Rathi, M. Andersson, R. Thobaben, J. Kliewer and M. Skoglund, "Equivocation of eve using two edge type LDPC codes for the erasure wiretap channel," in *Proc. Asilomar 2010.*

[167] R. Blasco Serrano, R. Thobaben, V. Rathi and M. Skoglund, "Polar codes for compress-and-forward in binary relay channels," in *Proc. Asilomar 2010.*

[168] S. Chatterjee, D. Sundman and M. Skoglund, "Statistical post-processing improves basis pursuit denoising performance," in *Proc. IEEE ISSPIT 2010.*

[169] D. Sundman, S. Chatterjee and M. Skoglund, "On the use of compressive sampling for wide-band spectrum sensing," in *Proc. IEEE ISSPIT 2010.* **10 citations**

[170] S. Chatterjee, D. Sundman and M. Skoglund, "Robust matching pursuit for recovery of Gaussian sparse signals," in *Proc. IEEE DSP Workshop 2011.*

[171] R. Blasco Serrano, R. Thobaben and M. Skoglund, "Bandwidth efficient compress-and-forward relaying based on joint source-channel coding," in *Proc. IEEE WCNC 2011.*

[172] N. Schrammar and M. Skoglund, "Capacity bounds for the discrete superposition model of the Gaussian multiple-access channel," in *Proc. IEEE WCNC 2011.* **Paper award.**

[173] F. Gabry, R. Thobaben and M. Skoglund, "Outage performance for amplify-and-forward, decode-and-forward and cooperative jamming strategies for the wiretap channel," in *Proc. IEEE WCNC 2011.* **13 citations**

[174] M. Xiao, B. Slimane, M. Skoglund and J. Manssour, "Advances in network coding for IMT-advanced and beoynd," in *Proc. Wireless VITAE 2011.*

[175] C. Wang, M. Xiao and M. Skoglund, "Efficient multiple access protocols for coded multi-source multi-relay networks," in *Proc. IEEE ICC 2011.*

[176] J. Karlsson and M. Skoglund, "Lattice-based source-channel coding in wireless sensor networks," in *Proc. IEEE ICC 2011.*

[177] F. Gabry, R. Thobaben and M. Skoglund, "Outage performance and power allocation for decode-and-forward relaying and cooperative jamming for the wiretap channel," in *Proc. IEEE ICC 2011.*

[178] J. Du, M. Xiao and M. Skoglund, "Capacity bounds for backhaul-supported wireless multicast relay networks with cross-links," in *Proc. IEEE ICC 2011.*

[179] L. Wang, V. Fodor and M. Skoglund, "Cooperative communication for spatial frequency reuse multihop wireless networks under slow Rayleigh fading," in *Proc. IEEE ICC 2011.*

[180] S. Chatterjee, D. Sundman and M. Skoglund, "Look ahead orthogonal matching pursuit," in *Proc. IEEE ICASSP 2011.* **12 citations**

[181] A. Shirazinia, L. Bao and M. Skoglund, "Design of UEP-based MSE-minimizing rateless codes for source-channel coding," in *Proc. IEEE ICASSP 2011.*

[182] J. Karlsson, A. Gattami, T. Oechtering and M. Skoglund, "Iterative source-channel coding approach to Witsenhausen's counterexample," in *Proc. IEEE ACC 2011.* **10 citations**

[183] A. Zaidi, T. Oechtering, S. Yüksel and M. Skoglund, "Sufficient conditions for closed-loop control over a general half-duplex white Gaussian relay channel," in *Proc. IEEE ACC 2011.*

[184] M. Khormuji and M. Skoglund, "Noisy network coding approach to the relay channel with a random state," in *Proc. CISS 2011.*

[185] A. Zaidi, T. Oechtering and M. Skoglund, "Closed-loop stabilization over Gaussian interference channel," in *Proc. IFAC World Congress 2011.*

[186] T. Do, T. Oechtering and M. Skoglund, "Optimal transmission for the MIMO bidirectional broadcast channel in the wideband regime," in *Proc. IEEE SPAWC 2011.*

[187] T. Do, T. Oechtering and M. Skoglund, "Optimal transmission for the MIMO bidirectional broadcast channel in the wideband regime," in *Proc. IEEE SPAWC 2011.*

[188] M. Khormuji and M. Skoglund, "Noisy analog network coding for the two-way relay channel," in *Proc. IEEE ISIT 2011.*

[189] H. Farhadi, C. Wang and M. Skoglund, "On the throughput of wireless interference networks with limited feedback," in *Proc. IEEE ISIT 2011.*

[190] N. Schrammar, M. Andersson and M. Skoglund, "Approximate capacity of the general Gaussian parallel relay network," in *Proc. IEEE ISIT 2011.*

[191] M. Gerami, M. Xiao and M. Skoglund, "Optimal-cost repair in multi-hop distributed storage systems," in *Proc. IEEE ISIT 2011.* **17 citations** ⋆

[192] Z. Si, R. Thobaben and M. Skoglund, "Bilayer LDPC convolutional codes for half-duplex relay channels," in *Proc. IEEE ISIT 2011.* **11 citations**

[193] V. Rathi, R. Urbanke, M. Andersson and M. Skoglund, "Rate-equivocation optimal spatially coupled LDPC codes for the BEC wiretap channel," in *Proc. IEEE ISIT 2011.* **34 citations**

[194] S. Yao, M. Skoglund, T. Kim and H. V. Poor, "Half-duplex relaying based on quantize-and-forward," in *Proc. IEEE ISIT 2011.*

[195] K. Kittichokechai, T. Oechtering and M. Skoglund, "Secure source coding with action-dependent side information," in *Proc. IEEE ISIT 2011.*

[196] K. Kittichokechai, T. Oechtering and M. Skoglund, "On the capacity of a channel with action-dependent state and reversible input," in *Proc. IEEE ISIT 2011.*

[197] M. Khormuji and M. Skoglund, "Hybrid digital-analog noisy network coding," in *Proc. IEEE NETCOD 2011.*

[198] A. Shirazinia, L. Bao and M. Skoglund, "Anytime source transmission using UEP-LT channel coding," in *Proc. European Wireless 2011* (invited paper).

[199] S. Chatterjee, D. Sundman, M. Vehkapera and M. Skoglund, "Hybrid greedy pursuit," in *Proc. EUSIPCO 2011.*

[200] D. Sundman, S. Chatterjee and M. Skoglund, "Greedy pursuits for compressed sensing of jointly sparse signals," in *Proc. EUSIPCO 2011.* **10 citations**

[201] A. Shirazinia, L. Bao and M. Skoglund, "Distortion bounds on anytime source transmission using UEP channel coding," in *Proc. EUSIPCO 2011* (invited paper).

[202] P. A. Floor, A. Kim, N. Wernersson, T. Ramstad, M. Skoglund and I. Balasingham, "Distributed zero-delay joint source-channel coding for a bi-variate Gaussian on a Gaussian MAC," in *Proc. EUSIPCO 2011* (invited paper).

[203] L. Lu, M. Xiao, L. K. Rasmussen and M. Skoglund, “Efficient scheduling for relay-aided broadcasting with random network codes,” in *Proc. PIMRC 2011.*

[204] H. Do, T. Oechtering and M. Skoglund, “Capacity bounds for the Z-channel,” in *Proc. ITW 2011.*

[205] M. Vehkapera, S. Chatterjee and M. Skoglund, “Analysis of MMSE estimation for compressive sensing of block sparse signals,” in *Proc. ITW 2011.*

[206] Z. Si, M. Andersson, R. Thobaben and M. Skoglund, “Rate-compatible LDPC convolutional codes for capacity-approaching hybrid ARQ,” in *Proc. ITW 2011.*

[207] A. Zaidi, S. Yüksel, T. Oechtering and M. Skoglund, “On optimal policies for control and estimation over a Gaussian relay channel,” in *Proc. IEEE CDC 2011.*

[208] F. Gabry, R. Thobaben and M. Skoglund, “Cooperation for secrecy in presence of an active eavesdropper: A game-theoretic analysis,” in *Proc. ISWCS 2011.*

[209] M. Xiao and M. Skoglund, “On network coding with finite channel state information,” in *Proc. ISWCS 2011.*

[210] M. Khormuji and M. Skoglund, “Capacity achieving instantaneous relaying,” in *Proc. ISWCS 2011.*

[211] H. Do, T. Oechtering and M. Skoglund, “Noisy network coding approach for the interference channel with receiver cooperation,” in *Proc. Allerton 2011.*

[212] P.-N. Chen, C.-L. Wu and M. Skoglund, “A joint design of code and training sequence for frequency-selective block fading channels with partial CSI,” in *Proc. WCSP 2011.*

[213] P. A. Floor, A. Kim, T. Ramstad, I. Balasingham, N. Wernersson and M. Skoglund, “Transmitting multiple correlated Gaussian sources over a Gaussian MAC using delay-free mappings,” in *Proc. ISABEL 2011.*

[214] K. Kittichokechai, T. Oechtering and M. Skoglund, “Capacity of the channel with action-dependent state and reversible input,” in *Proc. Swe-CTW 2011.*

[215] A. Zaidi, M. N. Khormuji and M. Skoglund, “Nonlinear transmission strategies for a general half-duplex AWGN relay channel,” in *Proc. Swe-CTW 2011.*

[216] M. Andersson, A. Zaidi, N. Wernersson and M. Skoglund, “Nonlinear distributed sensing for closed-loop control over Gaussian channels,” in *Proc. Swe-CTW 2011.*

[217] D. Sundman, S. Chatterjee and M. Skoglund, “Look ahead parallel pursuit,” in *Proc. Swe-CTW 2011.*

[218] R. Blasco Serrano, R. Thobaben and M. Skoglund, “Polar codes for coordination in cascade networks,” in *Proc. IZS 2012.*

[219] S. Chatterjee, K. V. S. Hari, P. Hndel and M. Skoglund, “Projection-based atom selection in orthogonal matching pursuit for compressive sensing,” in *Proc. NCC 2012.*

[220] R. Wyrembelski, T. Oechtering, H. Boche and M. Skoglund, “Robust transmit strategies for multiantenna bidirectional broadcast channels,” in *Proc. International ITG Workshop on Smart Antennas 2012.*

[221] D. Sundman, S. Chatterjee and M. Skoglund, “A greedy pursuit algorithm for distributed compressed sensing,” in *Proc. IEEE ICASSP 2012.* **14 citations**

[222] L. Dössel, L. Rasmussen, R. Thobaben and M. Skoglund, “Anytime reliability of systematic LDPC convolutional codes,” in *Proc. IEEE ICC 2012.*

[223] E. Stathakis, M. Skoglund and L. Rasmussen, “On combined beamforming and OSTBC over the cognitive radio Z-channel with partial CSI,” in *Proc. IEEE ICC 2012.*

[224] Z. Si, R. Thobaben and M. Skoglund, “Dynamic decode-and-forward relaying with rate-compatible LDPC convolutional codes,” in *Proc. ISCCSP 2012* (invited paper).

[225] L. Bao, C. Fischione and M. Skoglund, “On rate allocation for multiple plants in a networked control system,” in *Proc. IEEE ACC 2012.*

[226] A. Shirazinia, L. Bao and M. Skoglund, “Sufficient conditions for stabilization in feedback control over noisy cannels using anytime rateless codes,” in *Proc. IEEE ACC 2012.*

[227] F. Gabry et al., “Secure broadcasting in cooperative cognitive radio networks,” in *Proc. Future Network and Mobile Summit 2012.*

[228] N. Schrammar et al., “Average throughput in AWGN cognitive fading interference channel with multiple secondary pairs,” in *Proc. CROWNCOM 2012.*

[229] E. Stathakis, M. Skoglund and L. Rasmussen, “On combined beamforming and OSTBC over the cognitive radio S-channel with partial CSI,” in *Proc. CROWNCOM 2012.*

[230] R. Blasco Serrano, J. Lv, R. Thobaben, E. A. Jorswieck, A. Kliks, M. Skoglund, "Comparison of underlay and overlay spectrum sharing strategies in MISO cognitive channels," in *Proc. CROWNCOM 2012.*

[231] T. Do, T. Oechtering and M. Skoglund, "Achievable energy per bit for the multi-pair MIMO bidirectional broadcast channel," in *Proc. EW 2012.*

[232] H. Do, T. Oechtering and M. Skoglund, "A New inner bound for the interference relay channel," in *Proc. IEEE CISS 2012* (invited paper).

[233] N. Schrammar and M. Skoglund, "Achievable rates for symmetric Gaussian K-user interference channels with strong interference," in *Proc. SNOW 2012* (invited paper).

[234] S. Huang and M. Skoglund, "Polynomials and computing functions of correlated sources," in *Proc. IEEE ISIT 2012.*

[235] K. Kittichokechai, T. Oechtering and M. Skoglund "Multi-stage coding for channels with a rewrite option and reversible input," in *Proc. IEEE ISIT 2012.*

[236] H. Do, T. Oechtering and M. Skoglund, "Layered quantize-forward for the two-way relay channel," in *Proc. IEEE ISIT 2012.*

[237] I. Bilal, A. Zaidi, T. Oechtering and M. Skoglund, "Managing interference for stabilization over wireless channels," in *Proc. IEEE MSC 2012.*

[238] M. Khormuji and M. Skoglund, "Input-distribution optimization for estimate-and-forward relaying," in *Proc. ISWCS 2012.*

[239] H. Farhadi, C. Wang and M. Skoglund, "Power control in wireless interference networks with limited feedback," in *Proc. ISWCS 2012.*

[240] S. Salimi, M. Skoglund, M. Salmasizadeh and M. R. Aref, "Pairwise secret key agreement using the source common randomness," in *Proc. ISWCS 2012.*

[241] Z. Si, R. Thobaben, M. Skoglund and T. Oechtering, "Bidirectional broadcasting by using multi-edge type LDPC convolutional codes," in *Proc. International Symposium on Turbo Codes & Iterative Information Processing 2012.*

[242] M. Andersson, R. Wyrembelski, T. Oechtering and M. Skoglund, "Polar codes for bidirectional broadcast channels with common and confidential messages," in *Proc. ISWCS 2012.*

[243] J. Du, M. Xiao, M. Skoglund and S. (Shitz) Shamai, "Short-message noisy network coding with partial source cooperation," in *Proc. IEEE ITW 2012.*

[244] M. Vehkaperä, Y. Kabashima, S. Chatterjee, E. Aurell, M. Skoglund and L. K. Rasmussen, "Analysis of sparse representations using bi-orthogonal dictionaries," in *Proc. IEEE ITW 2012.*

[245] S. Salimi and M. Skoglund, "Secret key agreement using correlated sources over the generalized multiple access channel," in *Proc. IEEE ITW 2012.*

[246] M. Andersson, A. Khisti and M. Skoglund, "Secret-key agreement over a non-Coherent block-fading MIMO wiretap channel," in *Proc. IEEE ITW 2012.*

[247] Z. Wang, C. Wang, M. Xiao and M. Skoglund, "On the achievable degrees of freedom of partially cooperative X networks with delayed CSIT," in *Proc. IEEE Globecom 2012.*

[248] E. Stathakis, L. K. Rasmussen and M. Skoglund, "Low complexity adaptive antenna selection for cognitive radio MIMO broadcast channels" in *Proc. IEEE Globecom 2012.*

[249] N. Schrammar and M. Skoglund, "Approximating the capacity of wireless multiple unicast networks by discrete superposition model" in *Proc. IEEE Asilomar 2012.*

[250] N. Schrammar, C. Wang, L. K. Rasmussen and M. Skoglund, "On the discrete superposition model of partially cognitive interference channels" in *Proc. IEEE Asilomar 2012.*

[251] S. Huang and M. Skoglund, "Computing polynomial functions of correlated sources: Inner bounds," in *Proc. ISITA 2012.*

[252] F. Naghibi, R. Thobaben, S. Salimi and M. Skoglund, "Layered LDPC convolutional codes for compression of correlated sources under adversarial attacks," in *Proc. ISITA 2012.*

[253] A. Shirazinia, S. Chatterjee and M. Skoglund, "Performance bounds for vector quantized compressive sensing," in *Proc. ISITA 2012.*

[254] S. Huang and M. Skoglund, "Linear source coding over rings and applications," in *Proc. Swe-CTW 2012*.

[255] M. Khormuji and M. Skoglund, "Feedback capacity of the bidirectional broadcast channel," in *Proc. Swe-CTW 2012*.

[256] P. Larsson, L. K. Rasmussen M. Skoglund, “Multilayer network-coded ARQ for multiple unicast flows,” in *Proc. Swe-CTW 2012*.

[257] M. J. Emadi, M. Khormuji, M. R. Aref and M. Skoglund, “On the achievable rate region of a state-dependent MAC with cooperating encoders,” in *Proc. Swe-CTW 2012*. **Paper award.**

[258] D. Sundman, S. Chatterjee and M. Skoglund, “FROGS: A serial reversible greedy search algorithm,” in *Proc. Swe-CTW 2012*.

[259] C. Wang and M. Skoglund, “On the achievable degrees of freedom in a class of multi-user half-duplex relay networks,” in *Proc. IEEE WCNC 2013*.

[260] H. Farhadi, C. Wang and M. Skoglund, “Distributed interference alignment and power control for wireless MIMO interference networks,” in *Proc. IEEE WCNC 2013*. **11 citations**

[261] Z. Wang, C. Wang, M. Xiao and M. Skoglund, “The two-hop MISO broadcast network with quantized delayed CSIT,” in *Proc. IEEE WCNC 2013*.

[262] T. Kim, S. Choudhury, K. Doppler and M. Skoglund, “Simultaneous polling mechanism with uplink power control for low power sensor nodes,” in *Proc. IEEE VTC Spring 2013*.

[263] H. Do, T. Oechtering and M. Skoglund, “Layered coding strategies for the interference channel with a relay,” *IEEE ITA 2013* (invited talk).

[264] A. Zaidi, T. Oechtering, S. Yksel and M. Skoglund, “Stabilization over Gaussian networks,” *IEEE ITA 2013* (invited talk).

[265] M. Gerami, M. Xiao, C. Fischione and M. Skoglund, “Decentralized minimum-cost repair for distributed storage systems,” in *Proc. IEEE ICC 2013.*

[266] R. Blasco Serrano, D. Zachariah, D. Sundman, R. Thobaben and M. Skoglund, “An achievable measurement-rate-MSE tradeoff in compressive sensing through partial support recovery,” in *Proc. IEEE ICASSP 2013.*

[267] A. Shirazinia, S. Chatterjee and M. Skoglund, “Analysis-by-synthesis-based quantization of compressed sensing measurements,” in *Proc. IEEE ICASSP 2013.*

[268] A. Shirazinia, S. Chatterjee and M. Skoglund, “Channel-optimized vecotr quanizer design for compressed sensing measurements,” in *Proc. IEEE ICASSP 2013.*

[269] D. Sundman, D. Zachariah, S. Chatterjee and M. Skoglund, “Distributed predictive subspace pursuit,” in *Proc. IEEE ICASSP 2013.*

[270] A. Zaidi, T. Oechtering and M. Skoglund, “On stabilization over the Gaussian interference channel,” in *Proc. European Control Conference 2013.*

[271] F. Gabry, S. Salimi, R. Thobaben and M. Skoglund, “High-SNR performance of amplify-and-forward relaying in Rayleigh fading wiretap channels,” in *Proc. IWCIT 2013.*

[272] M. J. Emadi, M. N. Khormuji, M. Skoglund and M. R. Aref, “Multi-layer Gelfand-Pinsker strategies for the generalized multiple-access channel,” in *Proc. IWCIT 2013.*

[273] S. Huang and M. Skoglund, “On achievability of linear source coding over finite rings,” in *Proc. IEEE ISIT 2013.*

[274] K. Kittichokechai, Y.-K. Chia, T. Oechtering, M. Skoglund and T. Weissman, “Secure source coding with a public helper,” in *Proc. IEEE ISIT 2013.*

[275] J. Du, M. Medard, M. Xiao and M. Skoglund, “Lower bounding models for wireless networks,” in *Proc. IEEE ISIT 2013.*

[276] H. Farhadi, M. Khormuji, C. Wang and M. Skoglund, “Ergodic interference alignment with noisy channel state information,” in *Proc. IEEE ISIT 2013.*

[277] I. Bilal, A. Zaidi, T. Oechtering and M. Skoglund, “Feedback stabilization over a Gaussian interference relay channel,” in *Proc. IEEE SPAWC 2013.*

[278] C.-L. Wu, M. Xiao and M. Skoglund, “Joint data and channel estimation using semi-blind MLSE algorithms,” in *Proc. IEEE SPAWC 2013.*

[279] M. Andersson, A. Khisti and M. Skoglund, “Secure key agreement over reciprocal fading channels in the low SNR regime,” in *Proc. IEEE SPAWC 2013* (invited paper).

[280] F. Naghibi, S. Salimi, R. Thobaben and M. Skoglund, “The lossless CEO problem with security constraints, ” in *Proc. IEEE ISWCS 2013.*

[281] F. Gabry, M. Girnyk, M. Vehkaperä, L. Rasmussen and M. Skoglund, “Large-system analysis of MIMO wire-tap channels with randomly located eavesdroppers,” in *Proc. IEEE ISWCS 2013.*

[282] S. Salimi, F. Gabry and M. Skoglund, "Pairwise key agreement over a generalized multiple access channel: Capacity bounds and game-theoretic analysis," in *Proc. IEEE ISWCS 2013.*

[283] M. Khormuji, T. Oechtering and M. Skoglund, "Capacity region of the bidirectional broadcast channel with causal channel state information," in *Proc. IEEE ISWCS 2013.*

[284] M. Girnyk, F. Gabry, M. Vehkaperä, L. Rasmussen and M. Skoglund, "On the transmit beamforming for MIMO wiretap channels: Large-system analysis," in *Proc. IEEE ICITS 2013.*

[285] Z. Wang, M. Xiao, C. Wang and M. Skoglund, "On the degrees of freedom of two-hop MISO broadcast networks with mixed CSIT," in *Proc. IEEE Globecom 2013.*

[286] H. Ghauch, T. Kim, M. Bengtsson and M. Skoglund "Interference alignment via adaptively controlled perturbations," in *Proc. IEEE Globecom 2013.*

[287] H. Farhadi, A. Zaidi, C. Fischione, C. Wang and M. Skoglund, "Distributed interference alignment and power control for wireless MIMO interference networks with noisy channel state information," in *Proc. IEEE BlackSeaCOM 2013* (invited paper).

[288] S. Huang and M. Skoglund, "On existence of optimal linear encoders over non-field rings for data compression with application to computing," in *Proc. IEEE ITW 2012.*

[289] H. Do, T. Oechtering, M. Skoglund and M. Vu, "Capacity region of a class of interfering relay channels," in *Proc. IEEE ITW 2012.*

[290] H. Do, T. Oechtering, M. Skoglund and M. Vu, "Gaussian interfering relay channels," in *Proc. IEEE Asilomar 2013.*

[291] D. Sundman, S. Chatterjee and M. Skoglund, "Parallel pursuit for distributed compressed sensing," in *Proc. IEEE GlobalSIP 2013* (invited paper).

[292] C.-L. Wu, M. Xiao, S.-L. Shieh, P.-N. Chen and M. Skoglund, "A two-phase maximum-likelihood sequence estimation for receivers with partial CSI," in *Proc. ICICS 2013.*

[293] E. Stathakis, L. K. Rasmussen and M. Skoglund, "Closed-form capacity formula for multi-antenna cognitive radio networks with asymmetric fading," in *Proc. IEEE ICC 2014.*

[294] P. Larsson, L. K. Rasmussen and M. Skoglund, "Analysis of rate optimized throughput for ARQ in fading interference channels," in *Proc. IEEE ICC 2014.*

[295] R. Blasco Serrano, R. Thobaben and M. Skoglund, "Communication and interference coordination," in *Proc. IEEE ITA 2014* (invited paper). ⋆

[296] H. Farhadi, M. N. Khormuji and M. Skoglund, "Pilot-assisted ergodic interference alignment for wireless networks," in *Proc. IEEE ICASSP 2014.* **Paper award.**

[297] A. Shirazinia, S. Chatterjee and M. Skoglund, "Distributed quantization for compressed sensing," in *Proc. IEEE ICASSP 2014.*

[298] A. Zaidi, T. Oechtering and M. Skoglund, "Stabilization of noisy plants over a Gaussian interference channel," in *Proc. IEEE IWCIT 2014.*

[299] M. J. Emadi, M. Khormuji, M. Skoglund and M. R. Aref, "The generalized MAC with partial state and message cooperation," in *Proc. IEEE IWCIT 2014.*

[300] J. Du, M. Medard, M. Xiao and M. Skoglund, "Scalable upper bounding models for wireless networks," in *Proc. IEEE ISIT 2014.*

[301] F. Naghibi, S. Salimi and M. Skoglund, "The CEO problem with secrecy constraints," in *Proc. IEEE ISIT 2014.*

[302] S. Huang and M. Skoglund, "Supremus typicality," in *Proc. IEEE ISIT 2014.*

[303] K. Kittichokechai, T. Oechtering and M. Skoglund, "Lossy source coding with reconstruction privacy," in *Proc. IEEE ISIT 2014.*

[304] D. Xu, K. Kittichokechai, T. Oechtering and M. Skoglund, "Secure successive refinement with degraded side information," in *Proc. IEEE ISIT 2014.*

[305] N. Moghadam, H. Farhadi, P. Zetterberg and M. Skoglund, "Test-bed implementation of iterative interference alignment and power control for wireless MIMO interference networks," in *Proc. IEEE SPAWC 2014.*

[306] E. Stathakis, L. K. Rasmussen and M. Skoglund, "Characterization of outage performance for cognitive relay networks with mixed fading," in *Proc. IEEE Asilomar 2014.*

[307] P. Larsson, L. K. Rasmussen and M. Skoglund, "Analysis of rate optimized throughput for large-scale MIMO-(H)ARQ schemes," in *Proc. IEEE Globecom 2014.*

[308] P.-H. Lin, F. Gabry, R. Thobaben, E. Jorswieck and M. Skoglund, “Clean relaying in cognitive radio networks with variational distance secrecy constraint,” in *Proc. IEEE Globecom 2014.*

[309] F. Naghibi, S. Salimi and M. Skoglund, “On transmission of a remote source with secrecy constraints over noisy channels,” in *Proc. IEEE GlobalSIP 2014*, (invited paper).

[310] L. P. Cao, T. Oechtering, R. Schaefer and M. Skoglund, “Optimal transmission rate for MISO channels with joint sum and per-antenna power constraints,” in *Proc. IEEE ICC 2015*.

[311] Z. Wang, M. Xiao, M. Skoglund and H. V. Poor, “Secrecy degrees of freedom of the two-user MISO broadcast channel with mixed CSIT,” in *Proc. IEEE ITW 2015*.

[312] P.-H. Lin, F. Gabry, R. Thobaben, E. Jorswieck, M. Skoglund, “Multi-phase transmission for secure cognitive radio networks,” in *Proc. IEEE ICC 2015*.

[313] M. A. Girnyk, F. Gabry, M. Vehkaperä, L. K. Rasmussen, M. Skoglund, “MIMO wiretap channels with randomly located eavesdroppers: Large-system analysis,” in *Proc. IEEE ICC 2015*.

[314] H. Farhadi, H. Ghauch and M. Skoglund, “Pilot-assisted Opportunistic user scheduling for wireless multi-cell networks,” in *Proc. IEEE ICC 2015.*

[315] H. Farhadi, E. S. Nadimi, J. Atai, K. Pahlavan, M. Skoglund and V. Tarokh, “A novel adaptive localization technique for wireless capsule endoscopy,” in *Proc. SAGES 2015 Surgical Spring Week.*

Book Chapters (starting from 2007)

[316] M. Khormuji and M. Skoglund, “Near-optimal nonlinear forwarding strategy for two-hop MIMO relaying,” in *Wireless Communications*, InTech - Open Access Publisher, 2011.

[317] A. Zaidi, T. Oechtering, S. Yüksel and M. Skoglund “Stabilization and control over Gaussian networks,” Information and Control in Networks. Lecture Notes in Control and Information Sciences, vol. 450, 2014, pp 39-85. Springer Verlag.

[318] M. A. Girnyk, F. Gabry, M. Vehkaperä, L. K. Rasmussen and M. Skoglund “On the transmit beamforming for MIMO wiretap channels: Large-system analysis,” Information Theoretic Security. Lecture Notes in Computer Science, 2014, pp 90-102. Springer Verlag.

[319] H. Farhadi, N. N. Moghadam, P. Zetterberg, M. Khormuji and M. Skoglund, “Interference alignment: Practical challenges and test-bed implementation,” InTech - Open Access Publisher, 2014.

Patents

[320] P. Händel, M. Pettersson and M. Skoglund. “Method and system for calibrating analog-to-digital converters,” *U.S. Patent 6,127,955*, October 2000 (filed November 1998).

[321] P. Händel, M. Pettersson and M. Skoglund. “Full scale calibration of analog-to-digital conversion,” *U.S. Patent 6,407,685*, June 2002 (filed June 2000).

[322] H. Lundin, P. Händel, M. Skoglund and M. Pettersson, “Adaptively calibrating analog-to-digital conversion,” *U.S. Patent 6,445,317*, September 2002 (filed December 2000).

[323] P. Händel, M. Skoglund, T. Andersson and A. Høst-Madsen, “Method and apparatus for estimating physical parameters in a signal,” *Swedish Patent 0003108-8 (520067)*, May 2003 (filed September 2000).

[324] H. Lundin, P. Händel and M. Skoglund, “Adaptively calibrating analog-to-digital conversion with correction table indexing,” *U.S. Patent 6,690,311*, February 2004 (filed September 2001).

[325] G. Jöngren and M. Skoglund, “Robust utilization of feedback information in space-time coding,” *U.S. Patent Application 09/797,951*, *WO Patent 2,001,069,800, 2001*, March 2001.

CV

Name: Mikael Skoglund	**Doctorial degree:** 1997-04-11
Birthdate: 19690114	**Academic title:** Professor
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Research education

Dissertation title (swe)

Dissertation title (en)

On Soft Decoding and Robust Vector Quantization

Organisation	Unit	Supervisor
Chalmers University of Technology, Sweden Sweden - Higher education Institutes	Inst för informationsteori	Per Hedelin

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20299. Annan elektroteknik och elektronik	91-7197-454-7	1997-04-11

Publications

Name: Mikael Skoglund	**Doctorial degree:** 1997-04-11
Birthdate: 19690114	**Academic title:** Professor
Gender: Male	**Employer:** Kungliga Tekniska högskolan

Skoglund, Mikael has not added any publications to the application.

Register

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The signature*from the applicant*confirms that:

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